National Park Service
U.S. Department of the Interior

Big Bend National Park, Texas

Fire Management Plan
Environmental Assessment

Fire Management Plan

Environmental Assessment

Big Bend National Park • Texas

Abstract
Big Bend National Park needs to update its fire management plan (FMP) incorporating new policies and advances in fire research and operations. In developing the FMP staff considered public health and safety, the use of fire to accomplish resource management objectives, the need to base the program on science, and that the process be open and cooperative. Three alternatives are retained for analysis in this Draft Environmental Assessment (EA). The No Action Alternative, Alternative A, follows the current management direction and is retained as a basis for comparing other "action" alternatives. Alternative A uses prescribed burns and manual thinning to protect developments. Restrictive decision criteria governing natural ignitions have resulted in suppression of most lightning strikes. Alternatives B and C maintain protection of developments and sensitive resources, but reduce the likelihood of high-severity fire by allowing more fire to reduce hazard fuels. Prescriptions and decision criteria are more flexible than under No Action allowing fuel loads to be reduced to safer levels more quickly. Under Alternative B there is confidence that despite decades of suppression, habitats and species will recover following potentially widespread fire. Proponents of Alternative C are more cautious and propose using fire effects information from research burns to understand how to introduce fire without compromising park values and resources. For these reasons, Alternative C is the NPS preferred and environmentally preferred alternative. Fire management strategies proposed for Big Bend National Park would result in some short-term adverse effects to plants, animals and views. Reduction of fuels, particularly in the Chisos Mountains, is expected to reduce the likelihood of high-severity fire resulting in long-term benefits for the park.

Public Comment
If you wish to comment on this Environmental Assessment, you may mail comments to the name and address below. This environmental assessment will be on public review for 30 days and we will accept comments until June 31, 2005. Please note that names and addresses of people who comment become part of the public record. **If you wish us to withhold your name and/or address, you must state this prominently at the beginning of your comment.** We will make all submissions from organizations, businesses, and from individuals identifying themselves as representatives or officials of organizations or businesses available for public inspection in their entirety.

Send comments to:
John H. King, Superintendent
Big Bend National Park
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Texas 79834

Direct technical inquiries to:	Richard Gatewood (Fire Ecologist) at 432-837-7056
Obtain the EA by:	Accessing the park web site at: www.nps.gov/bibe/home.htm or calling Raymond Skiles (BBNP Wildlife Biologist) at 432-477-1145

United States Department of the Interior • National Park Service • Big Bend National Park

Executive Summary

Overview

Big Bend National Park needs to update its fire management plan (FMP) to incorporate new policies and advances in fire research and operations. Original meetings suggested that any change in fire policy could lead to significant or controversial consequences under NEPA guidelines, thus an Environmental Impact Statement (EIS) was proposed. Analysis of the three fire management alternatives retained for consideration, however, suggests much smaller impacts than originally thought and none were found to be significant or controversial. Subsequently a notice of intent NOI was published in the Federal Register on December 17, 2004 to announce the change from drafting an EIS to draft an Environmental Assessment, hereafter EA. The level of analysis of effects is the same for both documents however the approval process, is more streamlined for an EA because its findings reveal no significant impacts to the environment from the proposed management actions.

Goals and objectives for the fire program, and resources and values most likely impacted by fire were identified at an internal scooping meeting at the park December 11 and 12, 2002. Staff used two documents, the NEPA mandatory topics and the NPS Environmental Screening Form to develop the direction for fire program activities and the three fire management alternatives. Two public scoping meetings were held at Alpine and Study Butte, Texas, on the 26 and 27th of June 2003, respectively, to comment on staff findings. NPS staff from Denver and Phoenix involved in the review of the EA amended the impact topics in November 2003. They expanded the scope of life and property to include neighbors and boundary issues, added two new topics, watershed effects and resources for the fire program, and enlarged vegetation to include fire effects to wilderness, unique habitats, and exotic species. An Interdisciplinary Team (IDT) representing resource specialists from the park together with a cooperating agency, the University of Arizona, has been primarily responsible for developing this EA.

Four themes and corresponding chapters shape this EA. Chapter I identifies the needs and purpose of the FMP in meeting fire program goals and objectives and the areas or topics most likely to be affected by fire within the park. These eight impact topics were distilled from the extensive list developed in the internal scooping meeting. They are (1) life and property, (2) visitor experience, (3) local economy, (4) vegetation (5) threatened and endangered species (6) cultural resources (7) watershed effects, and (8) resources for the park fire program. Chapter II examines alternative fire management approaches, dismisses unreasonable ones, and looks at how well the remaining alternatives meet the fire program goals. Chapter III provides the background for the impact topics. Chapter IV analyzes the potential environmental consequences of the proposed fire management alternatives on the impact topics.

Fire Management Alternatives

The fire management alternatives differ with respect the extent the four fire management tools are employed – (1) natural fire also called wildland fire or lightning ignitions, (2) suppression, (3) prescribed fire (ignited by management to accomplish resource objectives), and (4) non-fire treatments such as mechanical and manual thinning. Fire is used to accomplish resource objectives within fire management units (FMUs). FMUs are distinct areas of the park with designated fire management strategies.

Alternative A, the No Action Alternative, continues the management direction laid out in the Big Bend 1994 FMP. This alternative has two FMUs. FMU 1 is a geographic area containing developments, a mile buffer strip along the park boundary, populations of threatened and endangered species, cultural resource sites and a northwesterly triangle bounded by the northern park border and State Highway 118 and US Highway 385. Fuel reduction is achieved by prescribed burning and manual or mechanical thinning. Suppression of all other fires is mandatory in FMU 1 including along the park boundary to contain fire on federal lands. The second FMU 2 covers the rest of the park and allows natural ignitions. Strict criteria governing initial decisions on fires however, have meant few fires have been allowed to burn. These criteria were preceded by a overgrazing prior to the park's establishement which, coupled with suppression, have changed the park's fire regime allowing an increase in shrub cover in the desert. In the upper elevations of the park a reduction in fire occurance has served to increase the amount of dead and downed woody debris on the forest and woodlands floor and increase the density of trees and shrubs. This increase in avaible fuel increases the probability of high-severity fire that could forever affect endemic and charismatic species, and alter views and habitats greatly valued by the public.

Alternative B, or Full Wildland Fire Use also has two FMUs. The first FMU 1 contains the same elements as Alternative A without the northwestern area bounded by the highways and with more flexible criteria governing management of fire along the park boundary. Where neighbors agree, the one-mile boundary buffer under Alternative A has been removed to allow fires to burn to man-made or natural topographic barriers such as the rivers or dry washes, cliffs, roads or bare areas. Fire-fighting safety and efficiency is expected to be greatly improve, and impacts to soils and vegetation from suppression activities reduced. The second FMU 2 allows for wildland fire throughout the rest of the park where fires will be allowed to burn within prescriptions at low to moderate intensities. Decision criteria allowing natural ignitions are more flexible and broad under this alternative, and more natural ignitions are expected to reduce fuels, create mosaics of burned and unburned vegetation that would benefit wildlife, facilitate post-fire recovery and provide greater plant diversity. Prescribed fire objectives are to maintain or enhance mature woody vegetation, especially the long-lived, mature trees in the Chisos. Prescriptions to meet these objectives will need to be developed.

Proponents of Alternative B advocate urgent reduction of fuel loads, particularly in the Chisos where a major natural fire has been absent for over 100 years resulting in significant fuel increases. Resource managers acknowledge the growing risk of a stand-replacing fire as fuels buildup and fires continue to be suppressed under Alternative A. Allowing more natural fire is proposed even when the fire effects are unknown and may be adverse. Proponents of this alternative are confident that allowing more burns now will be less costly in the long-term than investing resources in high-cost suppression of a widespread, high-severity fire. Alternative B may ultimately reduce the risk of large-scale, high-intensity fires to a greater degree than the other alternatives.

Alternative C or Progressive Wildland Fire Use outlines a process for reintroducing fire safely while balancing public values and safety, responsibilities for rare and endangered species, and improving ecosystem health. This Alternative also has two FMUs. Prescriptions for protecting developments, threatened and endangered species, cultural resource sites and managing boundary fires are the same as FMU 1 in Alternative B. Under FMU 2 natural ignitions are allowed within prescriptions and where fuel levels indicate that wildland fire can burn safely, the same as Alternative B. To protect highly valued mature trees, charismatic, rare, and relict plant species in the Chisos, FMU 2 also has a Special Treatment Zone. Fires may be allowed within prescription depending on site, or suppressed until research results indicate likely outcomes. These proposed research fires form the third component of Alternative C aimed at supporting science-based management in the park. Fire effects will be monitored with respect to sensative species and habitats, at differing intensities, and in different seasons. This information builds on work begun in the late 1970s and early 1980s and will allow more informed management decisions on the reintroduction of wildland fire into sensitive habitats and landscapes, help facilitate the restoration of native grasslands, possibly maintain and enhance habitat of listed species, and contribute to the control of invasive exotics in concert with other measures.

Alternative C allows for the measured introduction of low to moderate intensity wildland fire particularly in the Chisos based on the results from research burns. These results provide the stepping-stones to understanding how to reintroduce fire safely into a landscape following overgrazing prior to the park establishment and 60 plus years of a fire suppression management policy. This alternative acknowledges that historical vegetation communities, and fire return intervals are not well documented and a more careful, research-based approach to introducing fire is warranted. Resource managers also acknowledge that fuel levels will continue to increase in the Chisos while research results are being understood and that a stand-replacing fire could occur before research results are applied.

Summary of Alternatives
Alternative A maintains the current direction suppressing most natural fires and allowing fuels to increase; Alternative B allows natural ignitions where fuels assessment has occurred, and may reduce hazard fuels quickest; and, Alternative C proposes research burns to gain knowlegdge about fire management in complex habitats to improve future management decisions, thereby providing greatest long-term protection of valued resources.

Elements Common to All Alternatives

Fuel treatments:

1. Wildland fire use: Wildland or natural fires are ignited by lightning and are most common preceding the summer monsoon followed by a second peak in mid July. More wildland fire is allowed under Alternatives B and C with flexible decision criteria governing ignitions. Resource managers prefer natural fire as a tool as it is more cost effective than prescribed burning of similar area, and it occurs during seasons when fires historically occurred. Fires are monitored daily or more frequently in accordance with the Fire Monitoring Handbook (UDSI 2003) and the Wildland Fire Implementation Plan. The park will continuously update information on fire location, size, behavior, smoke dispersal, road closures and safety conditions, making this information available to every division within the park, and to merchants and visitors.

2. Prescribed fire: Under predetermined conditions or prescriptions, resource managers intentionally ignites fires to achieve resource objectives. Prescribed fire is proposed to reduce fuels around buildings, remove hazard fuels in the vicinity of cultural resource sites, maintain habitats of listed species, restore grasslands, or aid in the control of exotics, and where appropriate restore or maintain natural vegetation or reduce excessively high fuel loadings throughout the park.

3. Monitoring precedes and follows prescribed burns to record vegetation species and conditions and characterize fuel conditions and document changes following the fire. Surveys for cultural resources and sensitive species are also conducted prior to a prescribed burn and mitigating actions are taken. A prescribed burn program for the park began in 1980 and new projects outlined until 2012. Weather and fire behavior will be monitored throughout prescribed burns and mitigation measures developed prior to the burn. The Fire Monitoring Handbook (USDI 2003) will be used as a basis for monitoring but will be modified as more research data becomes available. Multiple low intensity prescribed burns may be needed to reduce fuels sufficiently to allow wildland fire to resume in some areas of Big Bend. The long-term objective is to, where reasonable, diminish the role of prescribed fire and to more fully allow naturally fire to resume its natural ecological role in the park. In time prescibed fire may be indentified as tool to use on an ongoing basis to maintain some sites, which may include cultural landscapes.

4. Non-fire treatments: Fuels may be reduced mechanically with chainsaws or manually with handheld tools to reduce fuels or create firebreaks. The park uses these methods around buildings and intends to also use them around historic buildings and sites where fire and or suppression activities could cause permanent damage. Expected expansion of the cultural resource inventory through monitoring activities will necessitate more attention to maintain these sites and possibly an increase in non-fire treatments.

Information collection

5. Monitoring is a key feature to gain knowledge about the dynamics of fire disturbance on vegetation. Baseline data on vegetation is required prior to prescribed burns for all alternatives. More monitoring

is proposed under the action alternatives to better understand fire effects on species and sensitive habitats, fire dynamics under different intensities to help meet natural and cultural resource objectives. Most monitoring will occur under Alternative C – pre and post-fire monitoring of research burns and prescribed fire, and all other fire related activities that may provide useful data and which the park has the resources to measure. Guidelines for monitoring are to meet criteria for scientific research and enable incorporation into management decisions and operations.

Management approaches

6. The park is guided by "Appropriate Management Response" (AMR) that assesses weather, staffing and available equipment, threats to resources, land use, regional issues and other concerns in making a management decision about whether to suppress, contain, or allow a fire to burn. It means that a variety of responses are possible for a given set of circumstances. Unplanned Human caused fires, such as from unattended camp fires, discarded cigarettes or arson, are automatically suppressed usubg tactics that causing the least amount of damage to resources, people and property. Minimal Impact Suppression Techniques (MIST) are tools available to achieve the AMR. MIST is employed to minimize damage to the landscape while providing safety and meeting resource protection objectives, especially in wilderness. Staging areas and firelines are placed where they will do least damage. Natural breaks are used where possible minimizing ground disturbance or tree cutting. Agency resource advisors will be consulted to determine appropriate management tactics. Heavy equipment such as dozers and road graders will not be allowed for fire suppression operations unlessed under extreme emergency conditions with the approval of the park superintendent.

Restoration and mitigation

7. Resource managers preplan to avoid fire accidents. Extreme conditions or sudden changes in weather do not always allow the prevention of damage to resources that may requires emergency stabilization and rehabilitation. Measures to initiate rehabilitation are developed in consultation with specialists such as archeologists, hydrologists, plant ecologists, and wildlife managers who help identify treatments and write the short and long-terms rehabilitation plan following a fire. They then help implement and monitor plans which may include cutting stumps, brushing handlines, recontouring drainage lines, removing trash, planting in burned areas, installing erosion control devices, and felling hazardous trees. Specific mitigative measures are outlined in Chapter II.

Education and communication

8. Communication is key to implementing the many components of a fire program. Methods of coordinating fire activities and notification of all park staff, concessionaires, neighbors and the public is being updated to improve fire-fighting efficiencies and public safety. Cooperation with neighboring landowners and agencies is in place under the existing FMP. Fine-tuning these park-neighbor agreements to allow suppression at natural or man made boundaries is expected to improve firefighter safety and reduce damage to soils and vegetation. Updating these agreements is an on-going process and will be pursued when staff resources are available. Further development of these agreements with state agencies moves the park towards interagency cooperation, a goal of the Federal Fire Policy. Agreements with Mexico and surrounding state agencies will help provide cohesive fire management of approximately 2.1 million acres of protected Chihuahuan Desert lands.

Unique to Alternative C

Research burns

Research burns are prescribed burns used to obtain specific information about fire effects on particular species or habitats, and to record fire dynamics under prescribd burning conditions. Collection of this information begun in the later 1970s and early 1980s, will guide restoration of particular habitats such as grasslands, improve understanding of how to stimulate or maintain diversity of species, to maintain or improve habitat for listed species, guide reintroduction of fire into heavily fueled areas, and increase understanding of how to use fire in the control of exotic plant species. Data collection priorities are understanding how to introduce fire in sensitive habitats where park values are at greatest risk.

Analysis of Environmental Impacts

Analysis of the effects of the three FMP alternatives was applied to the following eight impact topics.

Impact topic (1): Life and Property
Fire is an effective tool for reducing hazard fuels, but it is also a threat to the public, firefighters, park staff, developed areas, and neighboring properties.

Impact topic (2): Visitor Experience
Fire program activities may result in road closures and deter visitors; conversely some visitors are interested in fire and the post-fire activities offer interpretative opportunities.

Impact topic (3): Local Economy
Fire events provide business for local merchants and firefighters but may deter visitors. More routine fire events are likely to be better for the local economy than a single large high-severity fire.

Impact topic (4): Vegetation
Fire will benefit many species and habitats in the long-term but will kill and injure some plants in the short-term. Sensitive habitats require special consideration in fire planning. Allowing large-scale fire in wilderness maintains desirable mosaic patterns of burned and unburned vegetation. Fire can lead to increases in fire adapted exotic plants but can also contribute to their control.

Impact topic (5): Threatened and Endangered Species
Protecting federally listed species from fire require careful precautions to safeguard individuals, populations, and their habitats over the long-term; fire however, may be essential to maintain habitats.

Impact topic (6): Cultural Resources
Fire may help reduce hazard fuels and maintain historic views but can also damage and destroy structures, landscapes and artifacts.

Impact topic (7): Watershed Effects
Fire can remove vegetation and organic matter contributing to erosion and debris flows.

Impact topic (8): Resources for the Park Fire Program
The action alternatives propose more routine fire program activities and more natural ignitions; fighting fires safely, meeting monitoring, planning and compliance needs necessitates additional training, staff and resources.

All of these proposed fire management strategies would result in some short-term adverse effects, such as the death of individual plants and animals and disruption of habitat. Alternative A in allowing fuels to continue to increase across the park, may result in the greatest damage from high-severity fire under extreme weather conditions. An outcome of such fire in the Chisos may be the removal of soil organic matter initiating watershed erosion, destruction of soil seed sources slowing revegetation, and suppression activities damaging unidentified archeological sites and possibly converting woodlands and forests to shrubland orr grassland communities. Alternative B may reduce fuels at a greater rate, but in allowing more fire also increases the injury rate to plants and animals, and exposes firefighters to risk more frequently, and could result in undesirable unintended consequences. Outcomes over the longer-term are unknown but the threat of high-severity fire in the Chisos is reduced. Alternative C seeks to reduce fuels over a longer-time frame than Alternative B but sooner than Alternative A and reduce the potential for undesirable unintended consequences.

Resource managers understand that weather and climate dynamics may mean an extreme fire event or events could occur before the proposed management policies under Alternative B or C can realize their expected benefits. Should a high-severity fire occur under extreme conditions, it is possible that all alternatives will have the same outcomes – particularly in the Chisos Mountains.

Recognizing that fire is a natural feature in the Big Bend landscape, the park proposes under the preferred alternative, Alternative C, to reintroduce natural fire immediately where it is safe to burn, reduce fuels cyclically through prescribed burns to allow natural ignitions in the back country, expand protection for developments and cultural resources, and to learn more about fire effects and dynamics in sensitive habitats through research burns, fire effects monitoring or prescribed burns conducted in similar fuels and vegetation in other areas. Suppression over many years has translated into a liability for the park that is being addressed in this EA

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Chapter I : Introduction

Big Bend National Park is named for its location on the deep 100-mile-radius bend in the Rio Grande River in southwest Texas (Figure I-1). In authorizing a park in 1944, Congress recognized the area's rich biology, geology, cultural history, and outstanding recreational opportunities. International recognition of the park's resources came with a UNESCO Man and the Biosphere Reserve designation in 1976. Archeological sites dating back 10,000 years testify to the significance of the region to humans during prehistorical times. European efforts to colonize this area began in the 1500s heralding tumultuous times as Europeans, Mexicans and Native Americans fought for control until the late 1880s. The park now hosts an average of 300,000 visitors annually from across the United States and around the world. Visitors seek respite, scenic beauty, and recreational opportunities in the 801,000 acres of mountains, desert, and river, more than half of it proposed wilderness.

Purpose for Action

The purpose of this EA is to implement an improved fire management plan (FMP) for Big Bend National Park. The park is required to review its FMP and make appropriate changes on an annual basis with an update every five years. The approved plan will provide a framework for making fire-related decisions and serve as an operations manual. Updating the 1994 plan allows changes in fire policy, fire knowledge, burn results, and revisions in NPS policies to be implemented in practice. By incorporating changes in fire ecology, knowledge of fire effects and firefighting techniques, the FMP will better protect people, property and resources within the park. The proposed FMP provides an important transistion from the suppression era and the high-severity fires seen throughout the West to an era of allowing natural fires to shape and structure the parks vegetation as it had historically.

Need for Action

Current resource managers acknowledge four major challenges in managing vegetation at the park. The first is greatly increased fuels in forest and some woodlands increasing risk from high-severity fire. The second is an invasion of fire adapted nonnative species which threaten to displace native species primarily along the riparian corridor and drainages and potentially alter the fire regime from small low frequency fires to frequent, larger scale events. The third is altered fire patterns from historical overgrazing and suppression particularly in lowland desert grasslands. And the fourth is the prioritizing and meeting these challenges requires a significant shift in management direction for training, funding and support of project monitoring and evaluation, and commitment to implementing new policies over the long-term.

There has been no major fire in the Chisos Mountains for over 100 years. This may be part of a natural cycle as Moir estimated a conservative fire return ranging from 70 years using fire-scars in tree rings (1982). Early biological surveys described grasslands covering the Chisos Mountains (Schmidley, 2002) suggesting low-intensity, frequent grass-carried surface fires that would have maintained open woodland. Grazing since the 1880s, drought, and suppression till present day, have changed fire patterns altering historical vegetation types. In the absence of fire, fuels have accumulated increasing the risk of widespread, high-severity fire that would greatly impact the mountain woodlands and forests. Fire frequency and effects in low desert grasslands and desert scrub within the park is not well documented or understood. Large acreages of lands degraded by overgrazing may potentially be restored with careful use of fire, cycles of above average precipitation, and water retention techniques to aid grass seedling establishment. The proposed fire research program would build a platform for understanding how restoration might occur in lowland grasslands, endangered species habitats, and where nonnative plants have invaded. The 118-mile riparian corridor has dense stands of saltcedar and giantreed, with Bermuda grass and buffelgrass becoming well established along shorelines and drainages. Increased fire to benefit natural ecosystems may lead to expansion of nonnative species without accompanying commitment to post-fire control measures.

Assessments of the park in the 1940s and 1960s suggested that fire be reintroduced to counter changes in vegetation resulting from suppression and grazing. Staff shortages, limited resources and cautious administrators led to continued suppression of most natural ignitions under earlier FMPs (1973, 1978). A prescribed fire program began in 1980 to protect developments burned 1539 acres in 24 years. Two prescribed fires to develop defensible space and reduce fuels that did occur in backcountry, escaped, leading to new prescriptions under the proposed FMP to ensure greater safety. Over the same 24-year period there were 239 lightning caused fires, which burned 19,021 acres suggesting a need to allow more natural fires where they occurred historically.

The current 1994 FMP has two fire management units. All developments, historic structures, a one-mile buffer along the border, the Chisos and northwestern section bounded by US highway 385 and State Highway 118 are contained within a suppression zone. The park sought to prevent fire from leaving park boundaries and impacting neighboring landowners and valued resources. Prescribed burns and non-fire treatments were permitted. The rest of the park allowed wildland fire but it was rarely permitted to burn leading to increases in fuels and continued changes in vegetation structure and species.

The need for the current EA is to update the FMP to comply with NPS Director's Order #18: Wildland Fire Management (DO-18 1998) which requires each park with vegetation capable of burning to develop a FMP that considers safety for people and property and is responsive to the park's natural and cultural resource objectives. Completion of the proposed FMP will meet these requirements and provide direction for all fire related programs at the park by analyzing three fire management alternatives. Park staff intend that fire be carefully manged to maximize its benefits and minimize its dangers.

Policies and Regulations

The following regulations and guidance documents relate directly to the completion of a FMP and EA for the park.

National Environmental Policy Act (1969 NEPA) – The purpose of NEPA is to encourage productive and enjoyable harmony between humans and the environment; to promote efforts, which will prevent or eliminate damage to the environment and stimulate the health and welfare of mankind; and to enrich the understanding of the ecological systems and natural resources important to the Nation. NEPA requirements are satisfied by successful completion of an EA.

Director's Order –12 (DO-12, NPS 2001) – DO 12 is the NPS guidance for Conservation Planning, Environmental Impact Analysis, and Decision Making. DO-12 states the guidelines for implementing NEPA according to NPS regulations. DO-12 meets all Council on Environmental Quality (CEQ) regulations for implementing NEPA. In some cases, NPS has added requirements under DO-12 that exceed the CEQ regulations.

NPS Organic Act of 1916 – Congress directed the U.S. Department of the Interior and NPS in the Organic Act to manage units, "to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (16 U.S.C.§ 1). Congress reiterated this mandate in the Redwood National Park Expansion Act of 1978 by stating that the NPS must conduct its actions in a manner that will ensure no "derogation of the values and purposes for which these various areas have been established, except as may have been or shall be directly and specifically provided by Congress" (16 U.S.C.§ 1 a-1).

Director's Order-18 (DO-18, NPS, 1998) – DO-18 is the NPS guidance for Wildland Fire Management, which states that, "every NPS unit with burnable vegetation must have an approved Fire Management Plan." DO-18 defines what an approved FMP must include, stressing that "firefighter and public safety is the first priority" and promoting "an interagency approach to managing fires on an ecosystem basis across agency boundaries." Procedures for completion, review, approval, and required contents for FMPs are provided in Reference Manual-18 (RM-18). Until an FMP is approved, NPS units must take an aggressive suppression action on all wildland fires.

Policies affecting impact topics

1. Life and Property

NPS Management Policies (2001) Section 4.5– defines how the NPS will meet its park management responsibilities under the 1916 NPS Organic Act. The NPS recognizes that the presence as well as the absence of fire influences park landscapes, ecosystems, and operations. Management considerations are summarized below:

- parks with vegetation capable of burning will prepare fire management plans and address funding and staffing required by fire programs
- fire management programs will meet resource management objectives while ensuring protection of life and property
- fire plan development will include the NEPA compliance process and necessary collaborations with outside parties
- fires in vegetation are to be classified as wildland or prescribed fires and managed according to considerations of resource values, safety, and cost
- prescribed fires are ignited to achieve resource management goals and closely monitored to determine whether they successfully meet objectives
- parks lacking approved plans must suppress all wildland fires using methods that are the most cost effective while causing the least impact
- suppression in wilderness will be consistent with the "minimum requirement" concept

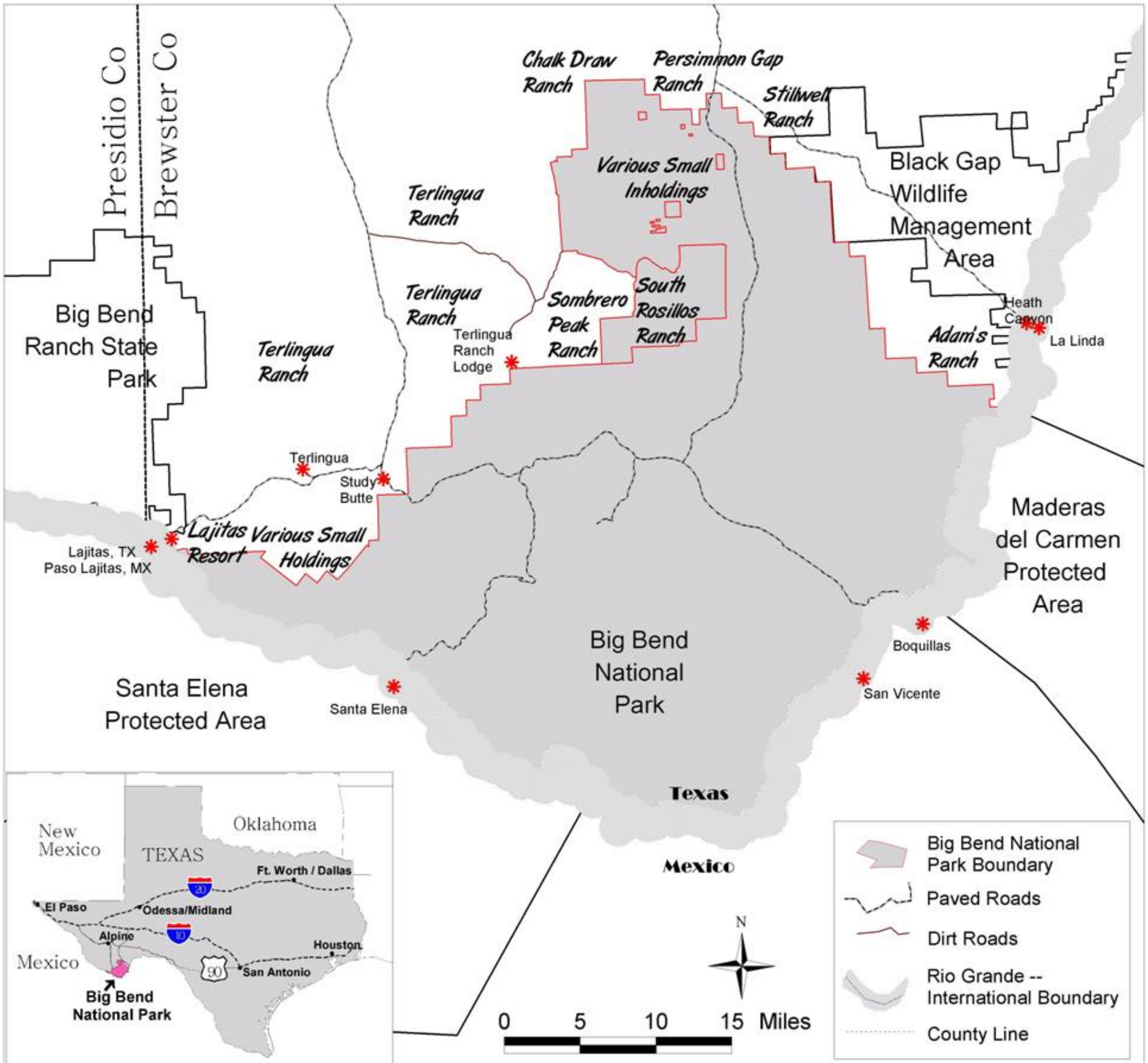

Figure I-1 Location of Big Bend National Park.

2. Preservation of Visitor Experience

NPS Management Policies (2001) – defines how the NPS will meet its park management responsibilities under the 1916 Organic Act.

Clean Air (as amended 1990) – includes national ambient air quality criteria; states that federal land managers have an affirmative responsibility to protect air quality related values from adverse impacts.

National Park's and Recreation Act (1978) - requires park management to preserve the park's resources by considering how development affects public enjoyment, identifying visitor carrying capacity; and proposing any boundary changes.

3. Local Economy

NPS Management Policies (2001) -defines how the NPS will meet its park management responsibilities under the 1916 Organic Act.

4. Vegetation

NPS Management Policies (2001) -defines how the NPS will meet its park management responsibilities under the 1916 Organic Act.

Executive Order 13112: Invasive Species (1999) – outlines definitions, guides management, monitoring and restoration guidelines for native vegetation.

Wilderness Act (1964) – requires all area of potential or designated wildereness be managed to maintain natural conditions.

5. Threatened and Endangered Species

Endangered Species Act/ Section 7 – provides for listing and protection of endangered and threatened species and their critical habitat; requires consultation under Section 7 if any listed species may be adversely affected.

Texas Department of Game and Fish – maintains state list of endangered and threatened, and sensitive species.

6. Cultural Resources

Archeological Resource Protection Act (1979) - provides for the protection of archeological resources on public lands.

American Indian Religious Freedom Act (1978) -protects access to sites, use and possession of sacred objects and freedom to worship through ceremonials and traditional sites.

National Historic Preservation Act/Section 106 – provides for the identification and protection of historic sites and structures.

Archeological Resources Protection Act (1979) - provides for the protection of archeological resources on public lands.

Executive Order 13007: Indian Sacred Sites (1996) – provides for the protection of Indian sacred sites.

Executive Order 11593: Protection and Enhancement of the Cultural Environment (1971) - preservation and enhancement of non-federally owned sites, structures and objects of historical, architectural or archaeological significance.

Historic Sites Act (1935) – provides for the preservation of historic sites, buildings, and objects of national significance for the inspiration and benefit of the people of the United States.

National Historic Preservation Act (1966) – a federal program to preserve historic properties.

NPS Director's Order #28 – defines how the NPS will meet its park management responsibilities under the 1916 NPS Organic Act to conserve scenery, natural and historic objects, and wildlife to provide for the enjoyment of future generations.

NPS Management Policies (2001) – defines how the NPS will meet its park management responsibilities under the 1916 NPS Organic Act.

Native American Graves Protection and Repatriation Act (1990-NAGPRA) - provides a process for museums and federal agencies to return certain Native American cultural items to their descendants and affiliated tribes.

7. Watershed Effects

NPS Management Policies (2001) -defines how the NPS will meet its park management responsibilities under the 1916 NPS Organic Act.
Executive Order 11990:Wetlands Management (1977) – provides for the protection of wetlands.
Executive Order 11988 Floodplains Management (1977) – provides for the protection of floodplains.
Clean Water Act and Section 404 regulations – provides for the protection of wetlands and waters of the U.S.

8. Resources for the Fire Program

NPS Management Policies (2001) -defines the values the NPS must protect under the 1916 NPS Organic Act. Federal funding is available for emergency firefighting and for fuels reduction on a competitive basis. As the park moves to allowing more wildland fire on a routine basis and carefully designed and monitored research burns, the funding options are less clear.

Other Plans, Policies, and Actions

Continuity between the plans and policies already in effect at the park must be maintained in developing this EA and FMP.

The General Management Plan (1981, draft 2003), the Statement for Management (1992), the Resources Management Plan (1988), and the FMP (1994) determine how Big Bend protects its resources. All plans recognize objectives directly related to comprehensive fire management. These documents emphasize the need for research to support management of natural resources, management across ecosystems, which requires the cooperation of private, state and Mexican landowners, and the preservation and interpretation of the park's many scenic geological, biological, cultural and historical features. The provisions in the proposed fire management plan and the mitigation measures listed in this EA are consistent with addressing these directions. In addition the IDT has examined the Federal Wildland Fire Management Policy (1995, Review and Update, National Interagency Fire Center, 2001) to ensure policies concur with national guidelines.

Contributors to the Plan

Five broad groups of people prepared the information for this EA and are working on the FMP. The groups are introduced below and give more detailed coverage in Chapter V (Consultation and Coordination).

- *Interdisciplinary Team (IDT):* The IDT is composed of NPS staff who are ultimately responsible for carrying out the plan. The staff has expertise in natural and cultural resources, fire operations, park administration, and visitor services. The Big Bend team also included a partner from the University of Arizona who served as overall editor for the EA.

- *Other Agency Cooperators:* Development of the plan included consultation with U.S. Fish and Wildlife Service, and Texas Parks and Wildlife on threatened and endangered species. The Black Gap Wildlife Management Area and Big Bend Ranch Park are being consulted about fire along park boundaries. The Texas State Historical Preservation Office was consulted about cultural resources.

- *Tribal Governments:* The seven tribes affiliated with the park are Apache Tribe of Oklahoma, Blackfeet, Comanche Tribe of Okalahoma, Kickapoo Traditional Tribe of Texas, Kiowa Tribe of Okalahoma, Mescalero Apache Tribe, and Ysleta Del Sur Pueblo. Tribes were not informed within the official comment period because of confusion about which tribes were affiliated with the park. Research by the park Tribal Liaison Officer, and staff in Santa Fe expanded the original list from 3 to 5 and finally to 7 tribes. Each will receive a copy of the draft EA and invited to comment on the alternatives.

- *Mexican Preserves:* The managers of the protected areas, Maderas del Carmen in the state of Coahuila, and Canyon de Santa Elena in the state of Chihuahua received notice of the park's planning process and were invited to participate. No comments were received. The preserve managers will continue to be invited to participate in planning meetings and efforts will be made to ensure they can attend meetings that jointly benefit management and operations of the park and preserves.

- *Interested Public*: The written comments of people who attended public scoping meetings, neighbors, and other interested members of the public have been considered during the development of this EA and FMP.

The Planning Process

Eighteen park staff members met on December 11-12, 2002 to discuss project objectives, issues, alternatives, NEPA's mandatory topics and the NPS Intermountain Regional Office Environmental Screening Form (IMRO ESF). An interdisciplinary team (IDT) from the park assisted in developing public scoping materials and hosting two public open houses on 26 and 27 June, 2003 at Alpine and Study Butte, respectively. The IDT team contains expertise in fire ecology and operations, natural resources including wildlife and vegetation management, cultural resources, and interpretation. As the EA was developed the team also sought assistance in Geographic Information Systems (GIS), hydrology, soils, and NPS law both within, and outside the park.

Goals and Objectives

The IDT developed six goals and objectives for the fire management plan at its December 11-12, 2002 meeting at the park and are listed in Table I-1. In identifying these goals, the IDT recognized that weather conditions and available resources may mean that the area burned can differ from the original plan. The team also stress the need for clearly identified goals for prescribed burns but flexibility to arrange prescribed burns when weather and resources permit.

Table I-1:Goals and Objectives of the Big Bend Fire Management Plan

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Goal 1: Protecting people and property is the highest priority of every fire management activity.

Objectives to achieve goal:

- Prevent injury to the public, staff, and fire personnel.
- Reduce fuels that could adversely affect life and property using prescribed fire, mechanical or other non-fire fuel reduction methods.
- Prevent human-caused wildland fires through public education.
- Maintain safe egress from all areas of the park in case of fire.

Goal 2: Apply wildland fire use, prescribed fire, non-fire fuel reduction measures, and fire suppression to accomplish natural resource management objectives.

Objectives to achieve goal:

- Determine the natural range of variability of the fire-return intervals.
- Determine desired conditions and condition classes for vegetation categories.
- Use fire as a restoration tool or as a maintenance tool.
- Monitor results of fire program activities and adjust management based on new knowledge.
- Where possible, ultimately allow fire to resume its natural role in park ecosystems.

Goal 3: Apply wildland fire use, prescribed fire, non-fire fuel reduction measures, and suppression to accomplish cultural resource management objectives.

Objectives to achieve goal:

- Use prescribed fire or non-fire fuels reduction tools to reduce fuels around sensitive sites.
- Restore and/or maintain cultural landscapes.
- Take advantage of surveying opportunities during and after fire operations.

Goal 4: Minimize unacceptable environmental impacts of fire program activities on natural and cultural resources.

Objectives to achieve goal:

- Properly plan each activity and conduct pre-action surveys.
- Carefully determine prescriptions.
- Suppress fires that fail to meet management objectives.
- Use minimum impact suppression tactics [MIST].
- Confer with resource advisors.

Goal 5: Cooperate fully with adjacent land management agencies and private landowners in the management of fire near park boundaries.

Objectives to achieve goal:

- Maintain communication and educate the neighbors about the fire program.
- Formalize relationships and conduct joint fire management activities with neighbors.

Goal 6: Coordinate fire activities with all park divisions, concessionaires, and the public.

Objectives to achieve goal:

- Maintain multiple lines of communication with all parties, in particular using the daily briefing sheet, website, and interpretive programs.
- Bring together structural and wildland fire planning operations.
- Incorporate appropriate fire management tasks into all park divisions.

Environmental Issues

This EA assesses the environment effects of three FMP alternatives proposed to meet the need and purpose of the new FMP. A NPS/UA interdisciplinary team (IDT) identified issues based on staff experience and knowledge of the park, application of the NPS Intermountain Region Environmental

Screening Form (IMRO ESF), and from public comments. Issues are problems, questions, concerns, or even benefits that could be caused by one or more of the alternatives. The complete list is retained as Appendix A. From this list the IDT then grouped issues into impact topics – issues where there is likely to be a greater than negligible impact despite mitigative measures. The eight impact topics derived from the discussion are listed below in Table I-2. The IDT also addressed the NEPA list of mandatory topics and compiled Table I-3 to show how they apply to Big Bend National Park. Those topics that do not apply to the park have been identified in the table and reasons given for their dismissal from further consideration in this EA. In November 2003, these eight impact topics were reviewed and amended with advice from NPS, state and regional representatives assisting with the development of park EA. Cooperative agreements with neighbors to manage fire along park boundaries, formerly a separate impact topic, were transferred to life and property, and exotic plants and unique habitats included with vegetation. Two new topics were suggested. These were watershed effects, and resources for the fire program. There are still eight topics but they include more considerations than the original determinations of the IDT.

Impact Topics

Safety is the first priority of any FMP and addresses the specific concerns of life and property (impact topic 1). Because fire may cross park boundaries, the impact on neighbors will also be considered under this topic. The park exists to provide a range of educational, recreational and scenic opportunities to the public, making visitor experience a key consideration (impact topic 2). Visitors are drawn to the park's cultural resources, including historic sites and landscapes, and these must be considered when managing for fire (impact topic 6). The parks' attractions and remote location make Big Bend National Park an important tourist destination in southwest Texas, and significant to the local and regional economy (impact topic 3). The park fire program exists because of the nature of the vegetation and its flammability. The park's botanical diversity, special plant communities and wilderness, together with the invasiveness of some exotic plants, pose distinct management challenges (impact topic 4). Many visitors travel to the park to see threatened and endangered wildlife found in few other NPS units (impact topic 5). Visitors particularly value the Chisos Mountains, which may experience impacts to the watersheds from widespread, high-severity fire (impact topic 7). In addition, the IDT recognized that additional resources were essential to allow the fire program to undertake more routine operations ensuring the objectives under all the impact topics were addressed over the long-term (impact topic 8).

Table I-2 Impact Topics

Impact Topic	Key Features
1. Life and Property	Fire is an effective tool for reducing hazard fuels, but it is also a threat to the public, firefighters, park staff, developed areas, and neighboring properties.
2. Visitor Experience	Fire program activities may result in road closures and deter visitors; conversely some visitors are interested in fire and the post-fire activities offer interpretative opportunities.
3. Local Economy	Fire events provide business for local merchants and firefighters but may deter visitors. More routine fire events are likely to be better for the local economy than a single large high-severity fire.
4. Vegetation	Fire will benefit many species and habitats in the long-term but will kill and injure some plants in the short-term. Sensitive habitats require special consideration in fire planning. Allowing large-scale fire in wilderness maintains desirable mosaic patterns of burned and unburned vegetation. Fire can increase exotic plants and also be used as a control tool.
5. Threatened & Endangered Species	Fire could directly kill or injure listed plant and animal species, and alter their necessary habitat conditions, but could also facilitate habitat improvement and reproduction for fire-adapted plants and wildlife.
6. Cultural Resources	Fire may help reduce hazard fuels and maintain historic views but can also damage and destroy structures, landscapes and artifacts.
7. Watershed Effects	Fire can remove vegetation and organic matter contributing to erosion and debris flows.
8. Resources for Fire Program	The action alternatives propose more routine fire program activities and more natural ignitions; fighting fires safely, meeting monitoring, planning and compliance needs necessitates additional training, staff and resources.

The Council on Environmental Quality guidelines state, "(m)ost important, NEPA documents must concentrate on the issues that are truly significant to the action in question, rather than amassing needless detail." (CEQ 1978). The following impact topics and issues specified in DO-12 or identified by park staff were carefully considered. "Topics retained for consideration" outlines issues central to the analysis of alternatives, and "Topics not retained for consideration" outlines reasons for dismissal from this EA.

Table I-3: NEPA Mandatory Topics

Category	How addressed
Topics retained for consideration throughout the EA	
Plans and Policies	Relevant plans and policies are listed above in this chapter.
Ecologically Critical Areas	These issues are addressed under impact topic (4) as unique habitats and as habitat for endangered species under impact topic (5).
Federally Listed Species	The park is consulting with U.S. Fish and Wildlife Service on a Biological Assessment (BA) that analyzes effects on three species, two animals and one plant lieky to be adversely affected by Fire Management Activities. The USFWS will issue a Biological Opinion once that determination is completed. In this EA, Chapter III provides background and Chapter IV summarizes the BA's analysis for federally listed species under impact topic (5).
Geohazards	Fire can alter watershed processes, which may affect erosion and flooding. High fuel loads in the Chisos increase the potential for high-severity fire, which burns soil organic matter creating hydrophobic soils and could lead to erosion and debris flows. This issue is addressed under impact topic (7) watershed effects.
Important Cultural Resources	The park has produced a Cultural Resources Component (CRC) analyzing cultural issues. In this EA, Chapter III provides background and Chapter IV summarizes the CRC's analysis; the summary matrix from the CRC is attached to this EA as Appendix C. Seven affiliated tribes with historical and/or contemporary ties to the park were consulted. Cultural resources are covered under impact topic (6).
Life and Property	These highest priority concerns are addressed under impact topic (1).
Socioeconomics	Fire may have beneficial effects on local businesses and seasonal firefighters. The public may be deterred from visiting the park during fire or after fire or they may be intrigued. The closure of the international border has limited economic and social exchanges to the detriment of both the US and Mexico. Potential effects are addressed under local economy, impact topic (3).
Wetlands and Floodplains	NPS is required to address effects of fire management actions on the Rio Grande floodplains (E.O. 11988) and major drainages. While there is significnat burnable vegetation in the floodplain and rivers the effect of fire will be greatest on vegetation with minimal effects on water quality and quantity. Wetlands have been severely altered by mining, agriculture and grazing. Fires there will have minimal effects to water quality and quantity Upland springs are addressed under impact topic (4) and Gambusia ponds under impact topic (5). Wetlands and floodplains will be dismissed as a sperate impact topic because we belive that effects will be adequetly address under impact topic (4).

Category	How addressed
Topics dismissed from further consideration in this EA.	
Air Quality	Big Bend NP is in a class I airshed. Fires cause short-term declines in air quality but are a minor source of pollution in the area. The park will meet Texas Commission on Environmental Quality's (TCEQ) regulatory standards and guidelines for all prescribed burns. In addition, emissions from wildland and prescribed fires are not regulated under federal or Texas state law unless there will be a permanent or long-term effect on air quality (Sandberg et al. 2002). For these reasons air quality was dismissed from further consideraton in this EA.
Energy Requirements and Conservation	Vehicle use to support fire management activities consumes fuel. A return to more natural fire processes saves resources consumed fighting fire. Because energy consumption is not a factor that affects selection of fire management strategies, the impact topic was dismissed from further consideration.
Consumption of Natural or Depletable Resources, and Conservation Potential	Fire and fire management activities consume renewable natural resources such as vegetation and water and non-renewable vehicle fuel. Consumption of vegetation is discussed under all impact topics. Because consumption of other resources is not a factor that affects selection of fire management strategies, this impact topic was dismissed from further consideration.
Urban Quality	Big Bend National Park is located within two sparsely populated rural counties. There are no urban centers abutting park borders, and nearby centers are located in sparse vegetation and unlikely to be directly impacted under the fire program. Therefore this impact topic was dismissed from further consideration.
Socially or Economically Disadvantaged Populations	There are no impacts predicted to fall predominantly upon disadvantaged populations. Big Bend National Park is located in sparsely populated Brewster and Presidio counties with fire operations benefiting small merchants and local firefighters. Therefore, this impact topic was dismissed from further consideration.
Prime and Unique Agricultural Lands	This impact topic was dismissed from further consideration because these lands are not found within the park, per Natural Resource Conservation Service, draft GMP 2003.
Land Use Conflicts	There are no land use conflicts predicted under the proposed alternatives and this topic was dismissed from further consideration in this EA.
Sacred Sites	There are no currently known sacred sites within the park. The issue is dismissed from further consideration in this EA but an open door policy remains to address tribal needs as they arise.
Indian Trust Resources	There are no Indian Trust Resources in Big Bend National Park, therefore this issue was dismissed from further consideration in this EA.
Water Quality	The Rio Grande is the major water body in the park. Water quality is greatly influenced by agricultural activities upstream over which the park has little influence, therefore this topic was dismissed from further consideration in this EA.

Chapter II : Fire Management Alternatives

Introduction

This chapter presents the range of fire management alternatives developed by the IDT, describes those alternatives that meet the park's needs, and justifies excluding other alternatives. The IDT developed the alternatives considering park policies, fire history within the park, fire literature, and experience and expertise of team members. Core elements included safety, ecology, public perceptions, cost-effectiveness, developing a fire database for the park, and drawbacks and benefits of proposed actions over the long-term. The limited public response during the scooping period supported the park preferred and environmentally preferred Alternative C. Each of the alternatives requires comparison with the current management direction, the no-action alternative, Alternative A.

Development of Alternatives

The IDT initiated possible alternatives using their experience, existing park plans, National Park Service Policies, the National Fire Plan and Federal Wildland Fire Management Policy, input from federal and state agencies, together with comments from the public and cooperators from the University of Arizona, School of Renewable Natural Resources. A small number of comments were received during two public open houses. Six members of the public and seven staff attended the first meeting at Sul Ross State University of 26 June 2003. The fire management officer and fire ecologist presented the alternatives and their implications and answered questions. The second meeting at the Study Butte Community Center on 27 June 2003 was supported by four staff and attracted three people. The public favored Alternative C that gradually increased wildland fire use based on research results. One member of the public supported Alternative B or full wildland fire use, if hazard fuels were sufficiently reduced. Three written comments were received supporting Alternative C.

Resource Analysis

Chapter III provides the environmental background for the alternatives introduced in this chapter. Fire history, fire ecology, and prescribed burn program results are summarized here. This background is needed to understand historical fire frequency and how managers and potential impacts of fire management options.

Fire History and Ecology

The effects of fire were investigated on higher elevation vegetation in the Chisos, and lower desert scrub and grasses. Researchers have sought to identify pre-European fire frequency by identifying fire scars in tree rings. Moir (1982), in reconstructing fire history of the Chisos Mountains, found 10 tree-scarring fires in Boot Canyon and the Southeast Rim with fires between 9 and 60 or more years apart conservatively estimating a fire-return interval of 70 years. In a study of 63 woodland sites throughout the southwest from 1700, Swetnam and Baisan noted fire return intervals of 1-89 years with a mean of 25 years (1996). In the Guadalupe Mountains Ashlstand (1981) noted mixed conifer forest averaged fire every five years from 1554-1842. In an effort to clarify fire trends for this region, Helen Mills at Yale University is currently undertaking a comparative study by of the Davis, Chisos and the Sierra Del Carmen Mountains to reconstruct historic vegetative structure and fire frequency. When resource managers know the historic range of variability for fire , they can identify restoration processes for small changes, or accept a type conversion.

The last sizable fire in the Chisos was in 1903. Lack of fire is attributed to grazing (from 1880s to 1940s,) drought (in 1890s and 1950s especially) and suppression (since grazing) which promoted shrub growth over grasses. That grasses once carried fire into the Chisos is suggested by government biological surveyor Vernon Bailey, who wrote in 1901, "Luxuriant grass covers almost the whole of the mountains….” and “Oaks, pines and junipers are the dominant trees…” suggesting frequent low-intensity fire, which kept woodlands open (Schmidley 2002:350). The current inflammability despite high fuel loads may reflect the topography of sheer cliffs, talus slopes and rocky terrain. The change of carrier fuels in forest areas from grasses to leaf litter, ladder, dead and downed fuels and small trees, will mean hotter fires, and may hamper efforts to maintain burns within prescriptions (Fule et al. 2004). The abundant high desert grasses noted by the surveyor Bailey, have taken 60 years without livestock to recover and could carry landscape scale fire into higher elevation woodlands and forests. McPherson (1995) estimates fire return intervals in desert grasslands at 7- 10 years, but this may need tempering to local fuel conditions.

The lower elevation desert contains mosaics of shrubs and grasses, and mixes of both depending on landform. Conditions prior to grazing can only be inferred. Mule train owners cut Chino grama, and perhaps tobosagrass to feed their animals (Gomez, 1991). Langford and Gipson described grasses as abundant “knee deep to a horse…only the tallest of the desert plants stood out above it”(1952). Other inferences by Tyler (1975), and Fulcher (1959) referred to periodic abundant grass and although these ranchers lacked scientist’s trained eyes, they knew grass turned cows into money. Overgrazing led to sheet and rill erosion, channel cutting and conversion to more drought tolerant shrubs rather than perennial grasses. Muldavin et al. (2001) examined vegetative changes in the park from 1955 to 1996 on 5 soil types and estimated it takes from 25-40 years for overgrazed sites to recover comparable vegetation, with recovery highly dependent on moisture.

That fire is the primary shaper of these ecosystems is debated. Hastings and Turner (1965) point to the paucity of fire in desert grasslands and the influence of other agents including human activity, climate, soils, drainage patterns, and rodent effect on seed sources – in shaping vegetation. Cornelius (1988) noted that recovery of desert shrubs after fire often exceeds that of dominant perennial grasses. A prescribed burn in 2003 in the northeast of the park however showed a slight increase in grasses within a year. Above average precipitation in the growing season and availability of seed sources may lead to greater establishment of grasses (Drewa and Havstad 2001; McKernan 2003; Muldavin et al. 2001). Fire is expected to be infrequent in these low biomass/ density assemblages where landform shapes moisture conditions (Wondzell et al. 1996). The shrub to grass ratio is dynamic ,shaped primarily by moisture (Muldavin et al. 2001) and then by fire and other agents.

The fire history data and precipitation records from 1948 to 2003, suggest that there is strong relationship between the amount of area burned in Big Bend National Park and the adjacent surrounding area and the amount of precipitation received in preceding years. Grass is the primary carrier fire at the park and the amount of grass increases with increasing precipitation. In drought years grass production is low and any grass grown in a preceding wet period will decrease thus limiting fire spread. However, during wetter periods more grass is produced and the ability of fire to spread increases (Figure II-1). The drought of the 1950’s and the most recent drought of the 1990s resulted in limited burned area. In contrast, the wet period of the last half of the 1980s resulted in several years where more than a 1000 acres were burned. Notably when the 5 year average precipitation exceeds 20.9 inches then the chance of burning more than 1000 acres is greater than 50% (Table II-1). While preciptitation is a major driver for vegetation dynamics in desert environments it is also a major driver for fire dynamics. The interrelationship of this two forces of nature is not well understood and will require further study to more fully understand fire’s role in the structure and function of desert vegetation.

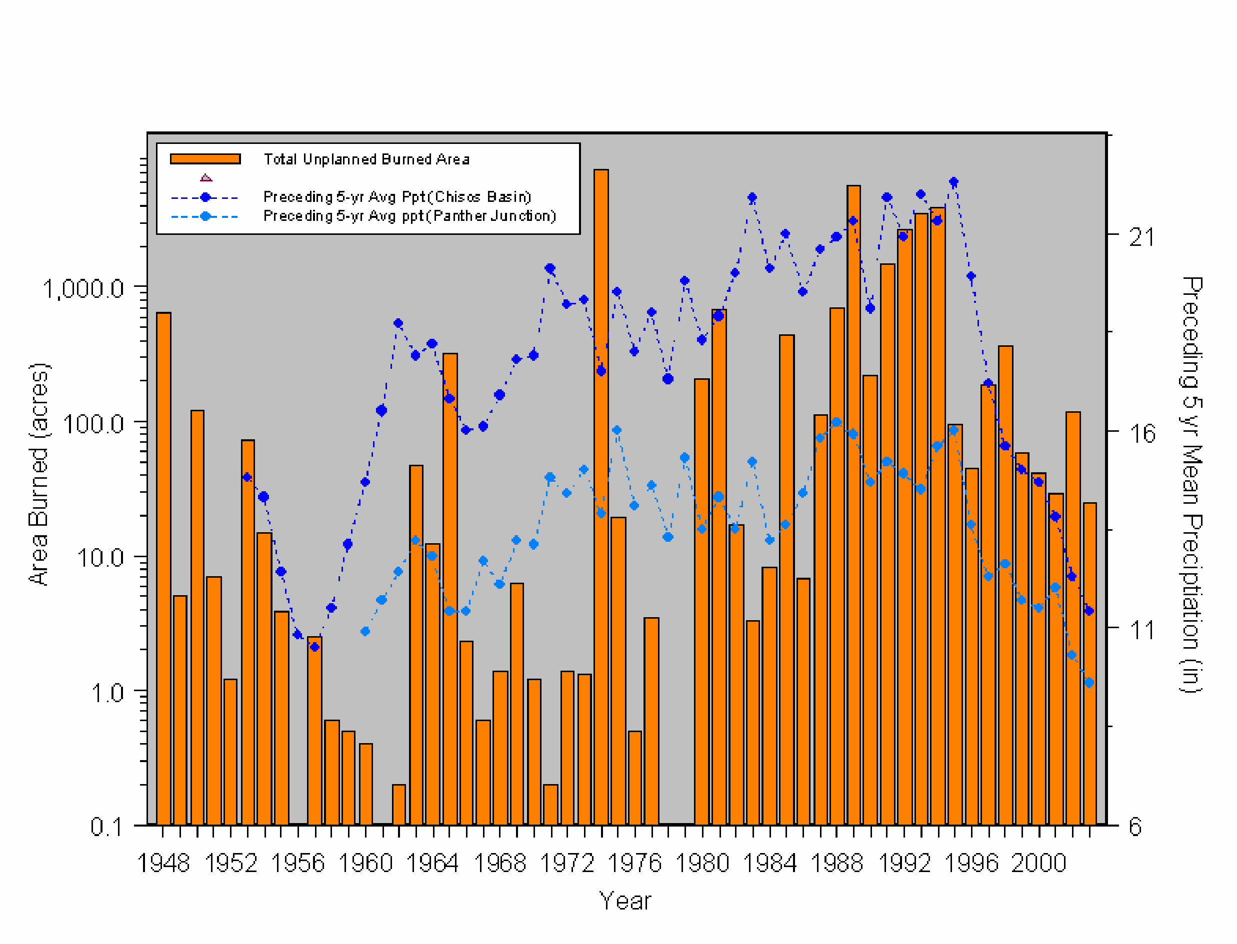


Figure II-1: Plot of the burned area for each fire year from 1948 to 2003 and the preceding 5-yr average precipitation. Each bar represents the total area burned in acres from all unplanned starts (Human and lightning) for that year. The two dotted lines are the preceding 5-yr average precipitation for the Chisos Basin (5400 ft elev.) and Panther Junction (3750 ft elev.) for that year. For example the precipitation value plotted for the fire year 1987, is the precipitation values averaged over the preceding 5 year period, 1982 to 1986.

Table II-1 Probability of occurrence for total burned area for Big Bend National Park and the adjacent surrounding area during any given the 5 year average precipitation preceding any given fire year.

Fire Year Burned Area (acres)	Preceding 5-yr Average Precipitation (inches) <14.0 (n=6 yrs)	14.0 to <20.9 (n=33 yrs)	≥20.9 (n=9 yrs)
<10	57%	47%	11%
10 to <100	29%	28%	11%
100 to <1000	14%	22%	22%
≥1000	0%	3%	56%

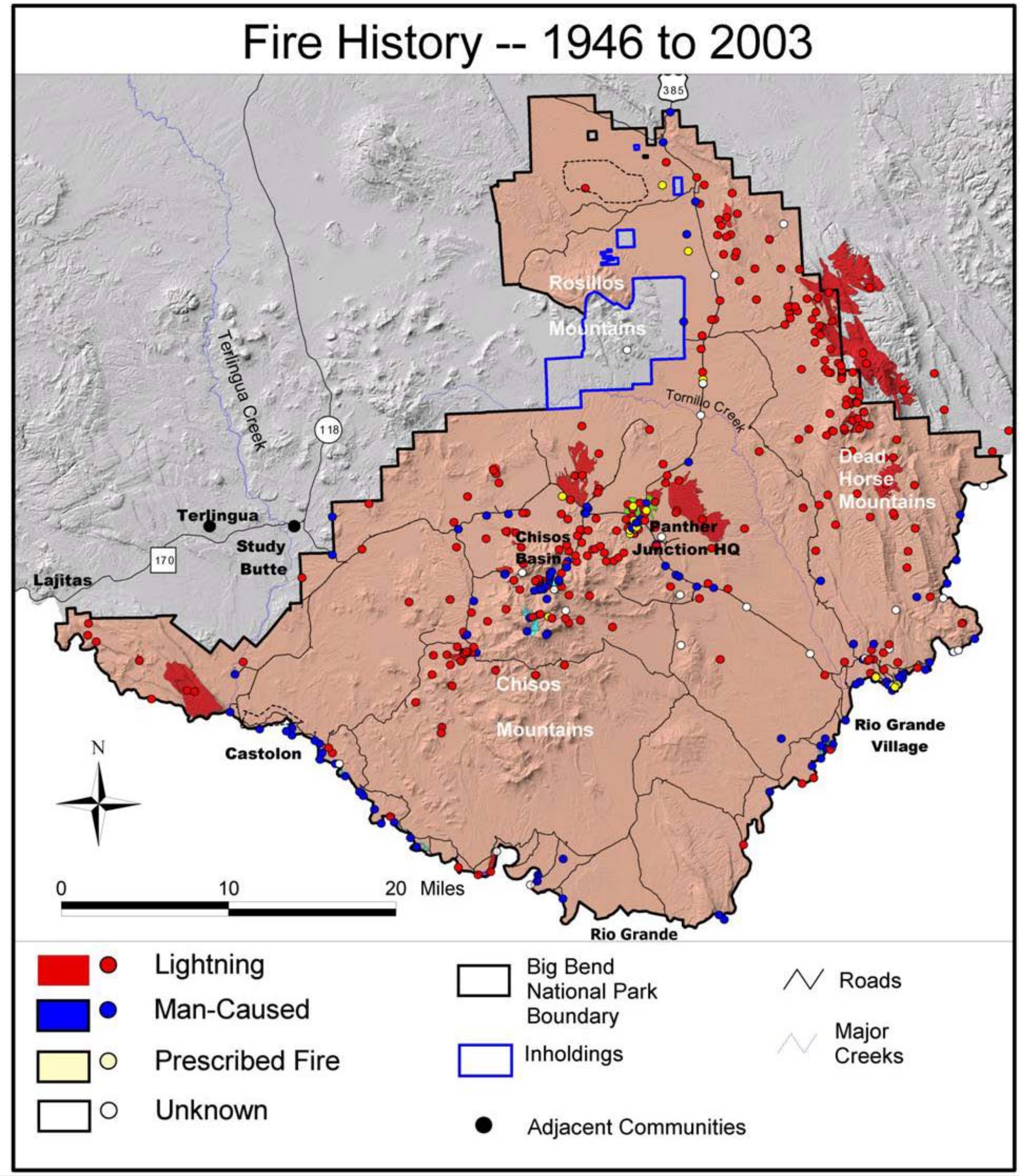


Figure II-2 Location of documented fires at Big Bend National Park

Big Bend Fire Program

Fire's role in maintaining diversity of plant and animal communities was recognized by the NPS as early as 1928 with calls to address the 'fire problem" (Welsh 2002). The need to reduce fuels in Big Bend been recognized for decades (McDougall et al. 1944; Leopold 1963). Authors of the park's three FMPs (1973, 1978 and 1994) concurred with these findings but staff and resource shortages have limited park actions. Prescribed burns since the 1980s addressed some needs outlined in the General Management Plan (1981), Resource Management Plan (1988), and current Fire Management Plan (1994) to reintroduce fire as a step towards reestablishing dynamic Chihuahuan Desert ecosystems. Most fire however, was targeted as prescribed burns around developments where 35% of all fires have occurred from 1946-2003. Since 1980, 31 prescribed burns consumed 1539 acres . While natural fire was allowed during this period cautious managers let few lightning ignitions burn. However, 239 natural ignitions burned 19,021 acres from 1946-2003 suggesting that there are sufficient fuels to support fire. The majority of wildland fires have been small, less than an acre in size (64%) but 9 more recently were >1000 acres. They were preceeded by several years of above average precipitation. The challenge facing managers is how to safely introduce fire as fuels continue to buildup in the Chisos increasing vulnerability to high-severity fire under extreme conditions.

Elements Common to All Alternatives

Tools of the fire program

The fire program toolbox consists of suppression, manual or mechanical thinning, prescribed burns and natural lightning ignitions for natural resource use, fuel reduction, and protection of cultural resource and park developments. Human caused fires have always been, and will continue to be suppressed immediately.

Appropriate Management Response (AMR)

AMR is the specific actions taken in response to a wildland fire. Suppression has been the most common response to natural ignitions in the park under the 1994 FMP but AMR recognizes that a number of appropriate responses may be possible for any set of circumstances. Managers weigh many factors in choosing the appropriate response including the resources at risk, fire use objectives, land use, weather conditions, and NPS regional priorities. The decision-matrix under the 1994 FMP (II-4) limited responses to fire events. Possible responses to wildland fire have been increased with a more flexible decision-making process following lightning ignitions under the action alternatives (Figure II-6). The AMR may lead to controlling fire (suppression), confining fire by allowing it to burn to natural boundaries, or containing it with a mix of natural boundaries and suppression actions. The park will continue to suppress any human caused fires with the least damage to people, resources and property. Fires would be monitored daily or more frequently in accordance with the Fire Monitoring Handbook (USDI 2003) and the Wildland Fire Implementation Plan. The park will continuously update information on fire size, location, behavior, smoke dispersal, safety conditions and effects.

Minimum Impact Suppression Techniques(MIST)

Just as AMR guides analysis of appropriate decisions for managing fire, minimum impact suppression techniques (MIST) guides selection of tools for managing fire. Wilderness areas in particular are to be managed in ways that minimize human impacts on the resource. Firelines along natural barriers such as the river, roads, trails, cliffs and talus slopes are sought wherever possible, and disturbance to the landscape, cultural and other resources minimized. Suitable sites for staging areas and spike camps have been located in previously disturbed campsites and developed areas. Agency resource advisors will be consulted prior to implementing management tactics.

Prescribed Fire Program

Prescribed fires are fires intentionally ignited by management. Since the 1980s park managers have used prescribed fire to reduce fuels around developments and to burn debris. Fires take place in specific areas under predetermined conditions identified in specific burn plans. Table II-3 lists the 31 burns covering 1539 acres that have occurredfrom 1980 to 2004. Naturally ignited fires are most plentiful just prior to summer monsoons from March through May when temperatures are hottest, fuels are driest, and lightning is plentiful, and again in mid to late July. Most prescribed burns are conducted outside the March 1 to July 15 fire season when conditions governing fire spread are less extreme and damage to plants is reduced. Proposed prescribed fires are listed in Table II-2 for reducing fuels around developments and historical sites, protecting habitat of federally listed species, and obtaining research data for restoration of particular species or vegetation assemblages. An estimated 7925 acres will be burned over the next decade to meet resource objectives.

A certified Prescribed Burn Boss will supervise appropriate levels of staffing for each prescribed fire under all three alternatives. Fire behavior and weather will be monitored during all prescribed fires using the NPS Fire Monitoring USDI (2003). Staff recognize that multiple burns are necessary to reduce fuels and change vegetative structure to allow wildland fire to assume its natural role. Annual reviews of prescribed burns allow lessons to be incorporated into plans for future burns.

Non-fire Fuels Treatments

Reducing fuels and creating firebreaks around property and cultural resources requires a degree of precision and containment not always present with prescribed or wildland fire-use. All alternatives allow use of mechanical tools including chainsaws, to remove brush or trees such as saltcedar trees from upland springs. Mowing facilitates reduction of grassy fuels along 110 miles of paved roadsides. Handheld tools may be used in wilderness areas to remove brush from historical sites or for horticultural use around developments. These non-fire treatments will represent a significant portion of the fire program resources under Alterantive C until acceptable fuel levels are established around developments and cultural resource sites. The fire program is partnering with other park departments to aid plant restoration efforts and reduce fuels around nominated cultural resource sites.

Wildland Fire Use

Staff want to allow lightning ignitions whenever they remain within prescriptions. Wildland fires can mimic historical fire occurance and may be the most cost-effective method for reducing fuel loadings to desired levels or condition classes (Table II-2). All alternatives allow natural ignitions within designated reas and within prescriptions. Administrative decisions have resulted mostly in suppression under the current FMP. Wildland fires under the action alternatives are assessed using more flexible decision criteria. Table II-3 lists 239 wildland fires from 1980 to 2004 burning a total of 19,021 acres.

Monitoring

Under all alternatives, pre-fire monitoring is required for prescribed burns to meet cultural resource and natural resource compliance. Monitoring plots are planned for all six vegetation categories to establish baseline information on species, vegetation structure, cover and height. These plots augment research begun in the late 1970s and early 1980s to develop databases that indicate fire effects over the long-term. The need for a research and monitoring program was noted in the 1994 FMP (p. 80-81). Post-burn information allows comparisons with earlier surveys, refinement of current prescriptions, and eventually may provide information for prescriptive fire plans. Post -fire monitoring is proposed for prescribed burns where such data will assist park resource objectives. Most monitoring data will be collected under Alternative C with pre and post-fire monitoring information for all research burns, and post-fire on prescribed burns and wildland fire when staff are available.

Communication and Coordination

Ignitions are reported to the fire office upon sighting and staff determines the cause of fire. All human caused fires are immediately suppressed. A cascade of environmental and administrative criteria are applied to all lightning caused fires to determine AMR. This step-wise process is outlined in II-4 for the current FMP and Figure II-6 for action alternatives. The Incident Commander, Prescribed Fire Boss or Fire Management Officer provide information to the Public Information Officer who disseminates briefs to all departments, to the visitors' centers to alert visitors of road closures or other inconveniences and to surrounding communities. Conditions are posted on the park web site and updated daily. The park proposes to increase communications particularly with the public as more routine fires are expected under the action alternatives, and because fires offer interpretive opportunities. Planned burns will be minimized during usual high-visitation periods of March through May. Fuels will be reduced along well-trafficked routes to reduce unintended fires and suppression applied around buildings and sensitive areas. Coordination with local landowners and managers is ongoing to minimize cumulative fire impacts on the region.

Interagency Communication

Interagency communication is perceived by the IDT as necessary for development of fire plans that conserve and preserve resources across 1.67 million acres of protected Chihuahuan Desert ecosystems. These reserves are Big Bend National Park, Blackgap Wildlife Management Area (Texas Nature Conservancy), Big Bend Ranch State Park (Texas Parks and Wildlife) and two Mexican preserves, Maderas del Carmen in the State of Coahuila, and Canyon de Santa Elena in the state of Chihuahua. In addition to developing agreements that allow for sharing of information, resources, and responsibilities among county (Brewster and Presidio Counties) state, federal and national institutions, the park wants to gradually incorporate more neighboring landowners into the information sharing process. The Fire Management Officer currently serves as liaison for this process. The park perceives long-term benefits from controlling fire at natural boundaries. Arbitrarily drawn administrative, legal or political boundaries having no regard for topography or vegetation potentially subjects fire fighters to unnecessary risks, and damages soils and vegetation through forced suppression boundaries– damage that could be avoided with more sensible control arrangements.

Emergency Plans

Recognition of the fuel loads and the danger of a single road into and out of the Chisos Basin led the park to develop plans for dealing with emergency fire situations (2003). Plans have also being developed for the Chisos high country to minimize the risk of fire from cigarettes and campfires. The Blue Creek fire (1989) and Laguna Meadow fire (1980) both occurred during the very dry pre-monsoon period of March through April, which also coincides with peak visitation in the park. When fire conditions are assessed as dangerous to extreme danger, a ranger is posted at main entrances to hiking trails for up to 10 hours a day to warn hikers and visitors of the danger. There are four main access points to the interlinked Chisos trails; Juniper Canyon, Blue Creek Canyon, Laguna Meadow and Pinnacles Trail. From these main trails Emory Peak, Boot Canyon, Colima Trail, Boot Spring, Northeast Rim and Southeast Rim can be accessed. It is proposed to link the Lost Mine Trail from Kibbe Spring to the Pinnacles Trail to the east and to Pine Canyon in the west. Hiking permits are issued with the fire danger caution attached, and at times smoking and campfires may be banned outside developed areas. The superintendent has the authority to close the backcountry to safeguard life and prevent human-caused fire.

To prepare for fire events in the park, the fire program has identified sites for firelines (bare earth without burnable materials), spike camps and staging camps. Natural firelines are sought and include talus slopes, rocky outcrops, roads and previously developed firelines in the park. Additional firelines will be developed in consultation with resource managers (wildlife biologist, archeologist, plant ecologist or hydrologist) appropriate to the resource being protected. Five sites for staging camps have been identified. Castolon and the Basin have been used in the past. Rio Grande Village campground, Kbar ranch, and San Vicente school area at Panther Junction during summer school vacation could all accommodate fire crews of up to several hundred people, including the traffic, communications and supplies necessary to handle large fires over three days or for more extended periods (type III incident). Spike camps could be located at Laguna Meadow, South Rim (campsites 1, 3, and 4) and at Boot Canyon if needed. These primitive campsites can accommodate about one hundred people during a fire event. Supplies would be brought in by mule packs or dropped by helicopter if wilderness restrictions are waived due to threats to life or property.

Mitigation of Undesirable Effects of Fire

Resource managers would continue reasonable efforts to avoid, minimize, and mitigate negative effects of the fire program. These include using best management practices under all alternatives to reduce any adverse impacts to human, cultural, and natural resources. Further, staff developed prescriptions, desired fuel loads, and designation of FMUs, were developed to minimize and mitigate negative effects under the fire program. Despite these efforts there may be need for short-term or long-term rehabilitation following fire. Staff will consult with specialists (archeologists, hydrologists, plant ecologists, wildlife biologists) to determine the treatments needed and then write, implement and monitor these plans. Common rehabilitation for environmental resources actions include: flush cutting stumps, replanting trees, removing trash, brushing in firelines, installing erosion control devices, felling hazardous trees, and carry out monitoring for short and long-term effects on vegetation and affected species. Damages to cultural resources from fire are usually permanent and cannot be rehabilitated; timbers burn, glass and metals melt, smoke blackens, and use of water or fire retardant may cause rock to crack. Below are measures specific to impact topics.

Impact topic (1) Life and Property and Impact topic (8) Resources for the Fire Program

- Reduce fuels with thinning, buffers and firebreaks particularly around developments.
- Use suppression (MIST) around buildings.
- Have evacuation plans ready for the Chisos.
- Avoid prescribed burning during high visitation periods.
- Minimize public exposure to burning events by closing roads and trails.
- Have personnel trained for needed tasks.
- Have sufficient personnel available or rapid access to a local or regional pool of trained and available staff.
- Coordinate with local agencies and managers to reduce cumulative impacts on region.

Impact topic (2) Visitor Experience

- Educate and notify neighbors, merchants and residents of all planned and unplanned park activities that have the potential to affect them.
- Provide quality interpretive experiences of the new FMP.
- Ensure the interpretive centers, web site, radio and interdivisional communications are current to reduce disruption of visitors and their plans.

Impact topic (3) Local Economy

- Ensure merchants and surrounding communities are notified of all prescribed and natural ignitions that may cause road closures and delay visitors.
- Provide local merchants and seasonal firefighters with opportunities to supply goods and services during fire events.
- Hire local people whenever possible for jobs in the park.

Impact topic (4): Vegetation and Impact topic (5): Threatened and Endangered Species

- Conduct prescribed burns outside breeding seasons.
- Create patchy burns leaving mosaics of vegetation that are refuges for animals and sources of reseeding.
- Keep up-to-date survey records of special status species.

- Locate potential firebreaks, staging camps and spike camps ahead of fire.
- Avoid using aircraft where it might disrupt nesting.
- Add rare species to GIS databases and continuing to build knowledge of life histories.
- Use refueling stations that protect against gasoline spills.
- Carry out rehabilitation immediately after fire if needed.
- Restrict prescribed fire to low and moderate intensity.
- Use Minimum Impact Suppression Techniques whenever possible.
- Measures specific to support Mexican long-nosed bat include burning when the park is wintering in Mexico, ensure 80 percent of agaves are maintained by patchy prescribed burns or suppression of wildland fire if needed, consult resource specialist.
- Follow Recovery Plan guidelines for federally listed species.
- Measures specific to support black-capped vireo include thinning and prescribed burns to protect key occupied territories, continue monitoring and do research on why suitable sites are not occupied, suppress any wildland fire that threatens territories, conduct any nearby burn outside the nesting and fledgling season.
- Measures specific to support Chisos Mountain hedgehog cactus include ongoing research into population dynamics, establishment and the removal of buffelgrass near affected individuals or populations.
- Measures specific to support Big Bend gambusia include ongoing monitoring, removal of giantreed at periodic intervals, prevention of gasoline entering the ponds, protection of cottonwoods against fire, restoration and replanting of the site if needed following fire.
- Manage wilderness in accordance with the Wilderness Act including: hand tools rather than mechanized tools and aircraft; no spike camps, crews or other personnel overnight; biodegradable retardant if it must be use; avoid spills, foam or erosion near water.

Impact topic (6): Cultural Resources

- Locate and identify sites vulnerable to fire effects prior to prescribed burns or mechanical thinning. Use an archeologist that meets the Secretary of the Interior’s standards.
- Follow protection measures for known cultural resource sites prior to prescribed burns, especially those vulnerable to fire and situated in or near the project area.
- Carry out post-fire surveys of natural ignitions whenever resources permit.
- Record new sites found during and after burns. Identify cultural resources park-wide to assist management of fire operations in future.
- Avoid ground disturbance during fire activities by identifying locations of potential natural firebreaks, spike campsites, and staging areas in previously surveyed areas. Do not construct fire control lines through cultural resource sites. Employ “Minimum Impact Suppression Tactics” whenever possible.
- Reduce fuels with thinning, buffers and fuel breaks.
- Locate vehicular routes away from cultural resource sites.
- Avoid using fire retardant near cultural resource sites.
- Work with tribes and work crews to protect ethnographic resources.
- Identify slash disposal areas away from all cultural resource sites.

Impact topic (7): Watershed Effects

- Initiate research burns to understand how to reduce fire safely in areas of heavy fuels.
- Allow low to moderate intensity natural ignitions where safe.
- Limit erosion following high-severity fire by creation of silt catchment devices at key points.
- Do research in lowland grasslands to better understand how to take advantage of natural conditions that foster grassland establishment.
- Support lowland desert grass reestablishment with water catchment, seeding and other measures whenever possible.

Table II-2: Schedule of prescribed burns under the three alternatives

Vegetation types: R=floodplain/riparian; DS = desert scrub; HDG = high desert grasslands; SW= shrub woodlands; GW= grassy woodlands; F= forest

Year/ month	Project name	Acres	Condition Class	Vegetation type	Purpose of treatment and monitoring objectives
2005	1314 Junction	531	II	HDG	Reduce hazard fuels and improve egress from Basin exit. *Monitor* shrub density, grass cover, species diversity, vegetation structure, recovery rates, agave mortality
2005	Boquillas Cyn Trailhead	10	III	R	Ecological restoration, fuel reduction, reduce saltcedar, exotics *Monitor* shrub density, grass cover, species diversity, vegetation structure, recovery rates, and non-native cover; cultural resources
2005	Panther Junction Blocks BC	29	II	HDG	Reduce hazard fuels *Monitor* shrub density, grass cover, species diversity, vegetation structure, recovery rates, and non-native cover
2006	Panther Junction Blocks EF-2nd entry	55	II	HDG	Reduce hazard fuels, defensible space *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, rate of recovery, nonnative cover
2006	Tobosa Grass Research Burn	10	II	DS	Research determine fire's role in restoring/ maintaining grasslands *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, recovery rates. Erosion rates. Percent grass recovering by seed & rhizome, soils erosion. Cultural resources
2006	Chisos Basin Blocks BCP	22	II	GW	Reduce hazard fuels, defensible space *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, recovery rates, nonnative cover, agave mortality
2006	SE Rim	370	II	GW/F	Reduce hazard fuels, retain species diversity, vegetation structure, reduce fuels, shrubs, uneven age stands *Monitor* dead and downed, tree density by size class, foliar and basal cover of herbaceous and woody species and surface cover
2006	Santa Elena Canyon Overlook	180	III	R	Ecological restoration, fuel reduction, reduce saltcedar, exotics *Monitor* shrub density, grass cover, species diversity, vegetation structure, recovery rates, and non-native cover; cultural resources
2006	Sublett Farm Floodplain- 1st entry	415	III	R	Ecological restoration, cultural restoration *Monitor* shrub density, grass cover, species diversity, vegetation structure, recovery rates, and non-native cover; cultural resources
2006	SW Rim Line Prep	26	I	GW/F	Reduce hazard fuels, maintain species diversity *Monitor* dead and downed fuels, tree density by size class, foliar and basal cover of herbaceous and woody species and surface cover. Monitor sensitive species
2007	Basin Campground Blocks FHKLMNO	67	II	SW	Reduce hazard fuels & create safety zone *Monitor* shrub density, grass cover, species diversity, vegetation structure, recovery rates, agave mortality and non-native cover
2007	Basin Block DEG	70	I	SW/GW	Reduce hazard fuels & create safety zone *Monitor* shrub density, grass cover, species diversity, recovery rates, agave mortality and non-native cover

Year/ month	Project name	Acres	Condition Class	Vegetation type	Purpose of treatment and monitoring objectives
2007	Alberico – Moir Long-term monitoring plots.	2.5	II/III	HDG/SW/GW/F	Reduce hazard fuels, assess first entry burns; a 2nd entry burn *Monitor* dead and downed fuels, tree density by size class, shrub density, foliar and basal cover of herbaceous and woody species, and surface cover
2007	RGV Campground	10	III	R	Reduce hazard fuels, removal of exotics, defensible space *Monitor* shrub density, grass cover, species diversity, vegetation structure, recovery rates, and non-native cover
2007	Gambusia pond	6	III	R	Wetland restoration *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, recovery rates, non-native cover
2007	Tamarisk thickets	3 x 20	III	R	Ecological restoration, removal of exotics *Monitor* tree density by size class, shrub density, foliar and basal cover of herbaceous and woody species, surface cover
2007	SW Rim Rx Burn	170	II	GW/F	Reduce hazard fuels, retain species diversity, vegetation structure, reduce fuels, shrubs, uneven age stands *Monitor* dead and downed, tree density by size class, foliar and basal cover of herbaceous and woody species and surface cover
2007	Green Gulch Mech Reduction A	8	II	HDG/SW	Reduce hazard fuels *Monitor* tree density by size class, shrub density, foliar and basal cover of herbaceous and woody species, surface cover.Cultural resources
2008	Johnson grass-Harte ranch	2	III	DS	Research fire & exotic species control *Monitor* % kill/recovery of exotic following fire + herbicide treatment, Shrub density, grass & shrub basal and foliar cover, species diversity. Cultural resources
2008	Buffelgrass – Johnson Ranch Road	2	III	DS	Research fire & exotic species control *Monitor* % kill/recovery following fire + herbicide treatment; shrub density, grass & shrub basal and foliar cover, species diversity, non-native cover. Cultural resources.
2008	Homer Wilson Ranch site	2	II/III	DS/HDG	Reduce hazard fuels *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, recovery rates, non-native cover
2008	Hannold Draw 2nd entry	484	II	DS	Reduce hazard fuels *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, recovery rates, non-native cover. Cultural resources
2008	Basin Blocks AIJ	13.5	II	SW	Reduce hazard fuels, improve defensible space *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, rate of recovery, nonnative cover
2008	PJ Blocks GHI	9	II	HDG	Reduce hazard fuels *Monitor* shrub density, grass cover, species diversity, vegetation structure, recovery rates, and non-native cover
2008	G. fescue micro burns	0.1	II	SW/GW/F	Fuels reduction; Research Guadalupe Fescue establishment *Monitor* fire effects on species, species diversity, Guadalupe fescue vegetative and reproductive response. Tree density by size class, shrub density, foliar and basal cover of herbaceous and woody species, surface cover
2008	Panther Junction Block D	52	II	HDG	Reduce hazard fuels *Monitor* Shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, recovery rates, non-native cover

Year/ month	Project name	Acres	Condition Class	Vegetation type	Purpose of treatment and monitoring objectives
2008	North Boundary or North Windmill (Chalk Draw)	200	II	DS	Reduce hazard fuels *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, recovery rates, non-native cover. Cultural resources
2008	Green Gulch corridor Mech Reduction B	8	II	HDG/SW	Reduce hazard fuels *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, recovery rates, nonnative cover, agave mortality. Cultural resources
2009	Basin (Sewer Lagoon to Panther Pass)	240	II	SW	Reduce hazard fuels in high use corridor. *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, rate of recovery, no-native cover, agave mortality, Cultural resources
2009	Johnson grass-Harte Ranch	2	III	DS	Research grasslands response to fire *Monitor* % kill/recovery of exotic following fire + herbicide treatment, Shrub density, grass & shrub basal and foliar cover, species diversity
2009	Buffelgrass-Johnson Ranch Road	2	III	DS	Research grasslands response to fire *Monitor* Percent kill/recovery of exotic following fire + herbicide treatment, Shrub density, grass & shrub basal and foliar cover, species diversity
2009	Homer Wilson Shearing Pen	1	III?	DS	Reduce hazard fuels *Monitor* Shrub density, grass & shrub basal and foliar cover, species diversity, recovery rates, non-native cover
2009	Lone Mountain 2nd entry	640	II	DS/HDG	Reduce hazard fuels *Monitor* Shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, recovery rates, non-native cover
2009	Dick-Peddie Plot 4/ Boot Canyon	0.1 acres	II	F	Research burn *Monitor* tree density by size class, shrub density, foliar and basal cover of herbaceous and woody species and surface cover. Cultural resources
2010	Basin Block BP	13	II	GW	Reduce hazard fuels *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, recovery rates, nonnative cover, agave mortality
2010	Panther Junction Block A	56	II	HDG	Reduce hazard fuels *Monitor* Shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, recovery rates, non-native expansion/invasion.
2010	Green Gulch West	200	II	HDG/SW	Reduce hazard fuels *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, recovery rates, non-native cover, agave mortality
2010	RGV/Boquillas Overlook	10	III	R	Reduce hazard fuels/control exotic species *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, recovery rates, non-native cover
2010	Green Gulch corridor Mech Reduction C	8	II	HDG/SW	Reduce hazard fuels *Monitor* Shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, recovery rates, non-native cover, agave mortality. Cultural resources
2010	RGV-Gambusia Wetland 2nd entry	10	I	R	Reduce hazard fuels *Monitor* photo points to observe changes in vegetation structure
2011	Green Gulch corridor Mech Reduction D	8	II	HDG/SW	Reduce hazard fuels *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, recovery rates, non-native cover, agave mortality. Cultural resources

Year/ month	Project name	Acres	Condition Class	Vegetation type	Purpose of treatment and monitoring objectives
2011	Toll Mountain	?	II	F/GW	Research burn – intensity effects *Monitor* tree density by size class, shrub density, foliar and basal cover of herbaceous and woody species and surface cover. Cultural resources
2011	Maple Canyon Basin	?	II	GW/SW	Reduce hazard fuels *Monitor t*ree density by size class, shrub density, foliar and basal cover of herbaceous and woody species and surface cover, agave mortality. Cultural resources
2011	Gambusia pond- 2nd entry	6	I	R	Wetland restoration *Monitor* recovery of natives including seedling establishment, pond flows and water table levels when possible. Cultural resources
2012	SE Canyon Overlook- 2nd entry	174	III	R	Ecological restoration, control exotic species *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, recovery rates, non-native cover
2012	Sublett Farm Floodplains- 2nd entry	415	III	R	Ecological restoration, cultural resource site, control exotics *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, recovery rates, non-native cover
2012	RGV Campground East	18	III	R	Reduce hazard fuels *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, recovery rates, non-native cover
2013	Casa Grande-2nd entry	230	I	GW/SW	Reduce hazard fuels *Monitor* tree density by size class, shrub density, foliar and basal cover of herbaceous and woody species, surface cover, agave mortality
2013	Basin Campground	70	II	GW/SW	Reduce hazard fuels *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, recovery rates, non-native cover, agave mortality
2013	Basin Block DEG	70	II	GW/SW	Reduce hazard fuels *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, recovery rates, non-native cover, age mortality
2013	Panther Junction Blocks BC-2nd entry	9	II	HDG	Reduce hazard fuels *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, recovery rates, non-native cover
2013	SE Rim-2nd entry	370	II	GW/F	Reduce hazard fuels, maintain species diversity *Monitor* tree density by size class, shrub density, foliar and basal cover of herbaceous and woody species and surface cover
2014	RGV Campground – 2nd entry	10	III	R	Reduce hazard fuels, control exotics, create defensible space *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, recovery rates, non-native cover
2014	Basin Blocks BCP	22	II	GW	Reduce hazard fuels, maintain defensible space *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, recovery rates, non-native cover, age mortality
2014	Panther Junction Blocks EF- 3rd entry	55	II	HDG	Reduce hazard fuels, maintain defensible space *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, recovery rates, non-native cover

Year/ month	Project name	Acres	Condition Class	Vegetation type	Purpose of treatment and monitoring objectives
2014	1314 Junction 2ND Entry Burn	531	II	HDG	Reduce hazard fuels *Monitor* shrub density, grass & shrub basal and foliar cover, species diversity, vegetation structure, recovery rates, non-native cover, age mortality
	TOTAL ACRES	**5984.2**			

While prescribed burns are often planned a year ahead, the availability of funding, weather, equipment and staff, determine when the burn can be conducted safely.

Range of Alternatives

Four fire management alternatives were considered by the IDT for their potentially different outcomes. The major differences were management strategies within the fire management units (FMUs), prescriptions governing wildland fire and prescribed fire use, control of fire along the park border, and the planning horizon for reducing hazard fuels.

Alternatives Retained for Analysis

Comparisons of the three alternatives retained for analysis are contained in Tables II-8, II-9 and II-10

No Action Alternative- Alternative A:

Organization

The existing (1994) plan uses two fire management units (FMUs) that are defined by specific fire management strategies. FMU 1 covers the Chisos Mountains, developments, a one-mile buffer inside the park border, and a section bounded by highway 385 from Persimmon Gap to Panther Junction west and north along highway 118 and dipping down to approximately Santa Elena overlook in the southwest. Prevailing summer winds and likely fire originate in the southwest suggesting this delineation was to preserve northern and western viewsheds rather than protect the southern and eastern flanks of the Chisos. The southern boundary is the mid-channel of 118 miles of the Rio Grande River, also the international border with Mexico. The river channel was treated as a wildland fire use area because the river formed a substantial barrier to fire and floodplain vegetation was sparse. Legally all wildland and prescribed fire is suppressed within a one-mile buffer along the park boundary to contain fire within federal lands. Administrative, legal, political and man-made features have prominently shaped the boundaries of this FMU, which contains developments, historic districts and other cultural resources, legally protected plant and animal species, and some wilderness. The arrangement of FMUs under Alternative A is illustrated in Figure II-3 below.

Tools for fire management in FMU 1 include suppression, prescribed fire and non-fire fuel treatments. Suppression protects developments at Panther Junction and Rio Grande Village, Historic Districts such as Burro Mesa, archeological sites, and federally protected species. Prescribed fire has been used to lower fuels primarily around buildings. Non-fire treatments include mowing along roadsides and use of chainsaws to remove saltcedar from upland springs.

The second FMU 2 with three fire subunits covers the eastern and southwestern drier and less flammable portions of the park. Most of this unit is proposed wilderness but includes Rio Grande Village and Castolon campgrounds, Mariscal Mines, Dugout Wells and Sam Nail Ranch historical sites, and other cultural and natural resources. Lighting ignitions are allowed if they meet predetermined management objectives but sparse and discontinuous fuels over much terrain carries fire for short distances before it lays down. Expansion of exotics particularly along the river corridor and up the arroyos (Guertin and Halvorson 2004) may change fire behavior in future. The full-spectrum of fire tools may be used in this FMU to meet resource objectives, protect infrastructure, cultural resources and listed species.

Outcomes

Authors of the existing plan established many of the same goals as the current IDT, and proposed a phased introduction of wildland fire, moving from the current suppression regime to natural fire across most of the park (p.5-6 old FMP). The FMP quotes staff and resource shortages, lack of training, access to basic decision-making data, protection of life and property, protection of cultural resources and interagency planning as all obstacles to full implementation of the fire program (p.7-8 old FMP). Park history also demonstrates that opportunities to introduce wildland fire were hampered by an inflexible decision-making tree for natural ignitions, that has continued the mostly suppression policy for 10 more years. This decision matrix is illustrated in Figure II-4. A total of 1539 acres were treated with prescribed fire since 1994 while 19,021 acres from 239 lightning strikes burned under natural ignitions. Table II-4 lists all prescribed burns since 1980.

Fuels continue to build in the Chisos moving from fuel model 8 to 10 in forest under the national fire policy rating system. There are few planned prescribed burns to lower fuels and limit the spread of wildlfire into the Chisos, and no plans to develop firebreaks in this wilderness. Staff are intrigued that although fuel loads are high and desert grasslands would carry fire from the slopes into the upper mountain reaches, ignitions observed during the monsoons have not led to active fires. Perhaps the rugged topography has stopped infant strikes at talus slopes or rocky outcrop, or perhaps relative humidities and fuel moistures have been too high to support fire. Whatever the reason(s), fires have occurred in the Chisos in the past, and higher fuel levels mean future fires are likely to be of higher intensities (energy released by fire) and severities (degree of burn to soil organic matter and canopy) than in the recorded past. Under wilderness designations minimum impact techniques must be applied in controlling fire in wilderness. These dictate use of non-mechanized equipment such as hand held tools rather than chainsaws and airborne retardants. These techniques limit ground disturbance and noise, but can be overridden by an incident commander or superintendent when life or property is deemed in danger.

The decision-making matrix used under the current FMP is illustrated in Figure II-4. All questions must be answered with a “yes” to allow a fire to burn.

Prescriptions for Wildland fire Use and Prescribed fire
Predetermined conditions for prescribed fires and wildland fires guide incident commanders in their preparation and response to fire events. Under the current FMP, prescribed fires have been contained around developments, but two have escaped while reducing fuels in natural areas. The difficulty of containing fire has led the fire program to reevaluate fire prescriptions, and training and monitoring needs to consider how to safely make the transition between high fuel loads and use of prescribed fire, to allowing more natural ignitions safely in the park.

Prescribed fire prescriptions for FMU 1 guides hazard fuel reduction, and debris disposal to meet air quality control guidelines. In FMU 2 prescriptions guide wildland fire use. The main criteria are:

- Regional and national preparedness level is II or less (preparedness level reflects local conditions for fire spread and regional and national availability of people and equipment for managing events—the higher the level, the more extreme the conditions and taxed the resources); may be restrictive (especially regionally) during the spring months when Planning Level 3 may apply.
- There must be 3 or fewer fires burning in the park at any one time.
- The fire must be caused by lightning and be in FMU 2.
- Any fire deemed to endanger life or property inside or outside the park will be suppressed.
- The burning index for fuel model T must be below 85th percentile for 4 consecutive days (burning index is an estimate of the relative potential difficulty of fire control based on how fast and hot a fire could burn; fuel model T predicts fire behavior for a mixture of woody shrubs and grasses).
- Fire spotting must be less than ¼ mile or suppression is required.
- Fire behavior over current and predicted 24 hours will not threaten FMU 2 border.
- Smoke does not exceed air quality standards.
- Other criteria fire based on fuel moisture, relative humidity and wind speed conditions are appendix F in the 1994 FMP.

Table II-3: Summary of prescriptions under 1994 FMP

Ranges	Level 1	Level 2	Level 3
Wind speed	8-16	5-10	4-6
Relative humidity	30-70	20-70	10-70
% Fuel moisture	8-16	6-8	4-6
Fuel models	1, 2, 3, 4, 6, 8, 9	1, 2, 3, 4, 6, 8, 9	1, 2, 3, 4, 6, 8, 9

Under the current prescriptions wind speed is perceived as the major factor determining fire effects. With higher winds, fuel moisture and relative humidity must be higher to ensure adequate control over fires. With declining wind speed, fuel moisture and relative humidity can be lower (drier) to achieve the same level of control. Some forest areas in the Chisos have been assessed as fuel model 10 and lie outside the above prescriptions.

Mitigative Measures

These are outlined under "Elements Common to All Alternatives." Alternative A does not reduce high levels of accumulated fuels particularly in forest, apply fire prescriptions that allow the introduction of fire in a manner that is consistent with naturally occurring ecological processes (assuming more frequent fire at low to moderate fire intensities), or restore fire-adapted plant communities that have been altered by human activities such as mining, grazing, cultivation and fire suppression. Implementation of this alternative under the 1994 FMP has not meet the goals outlined at that time and constitutes an increasing risk to park resources and values.

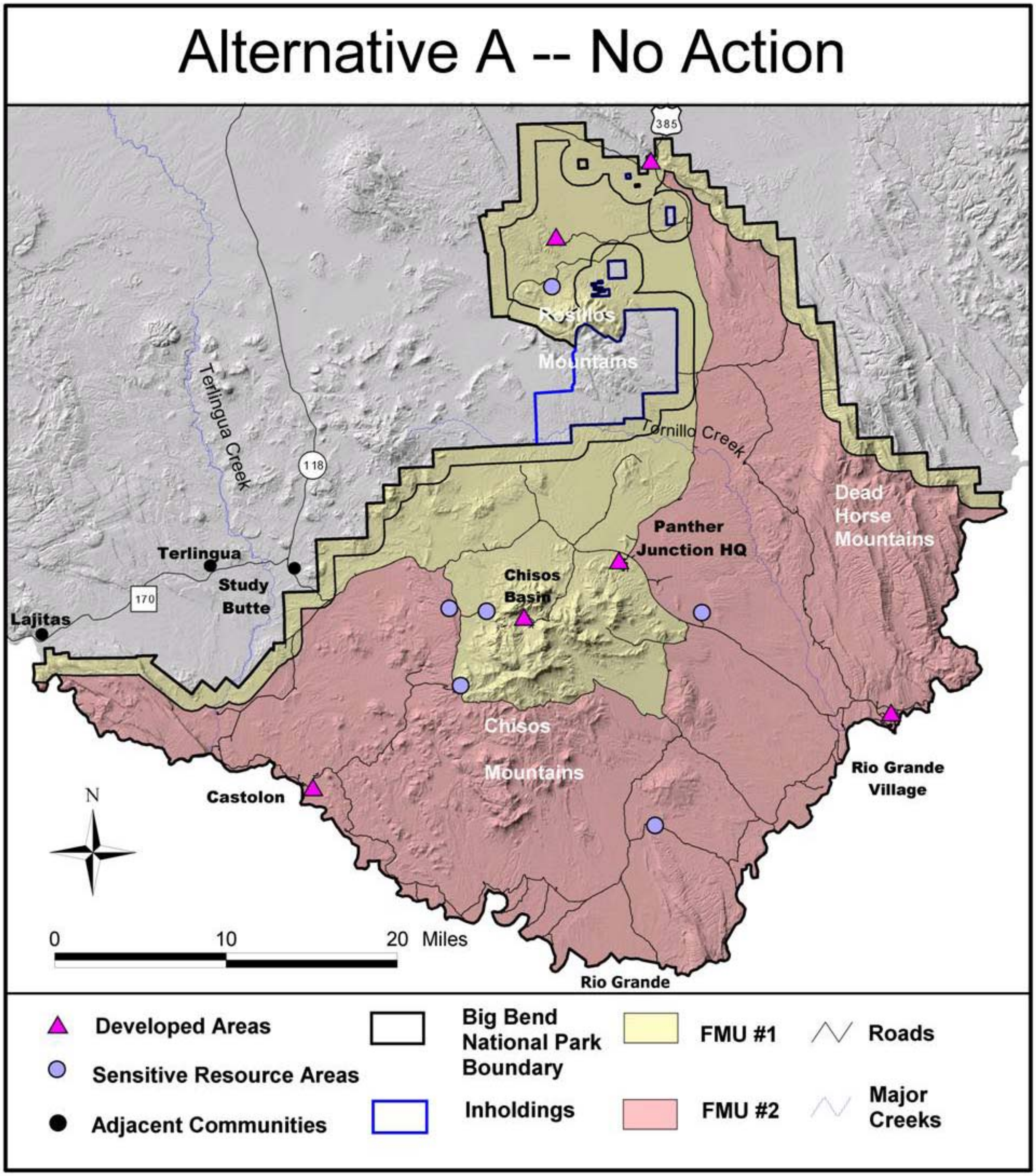


Figure II-3: Alternative A: No Action Alternative

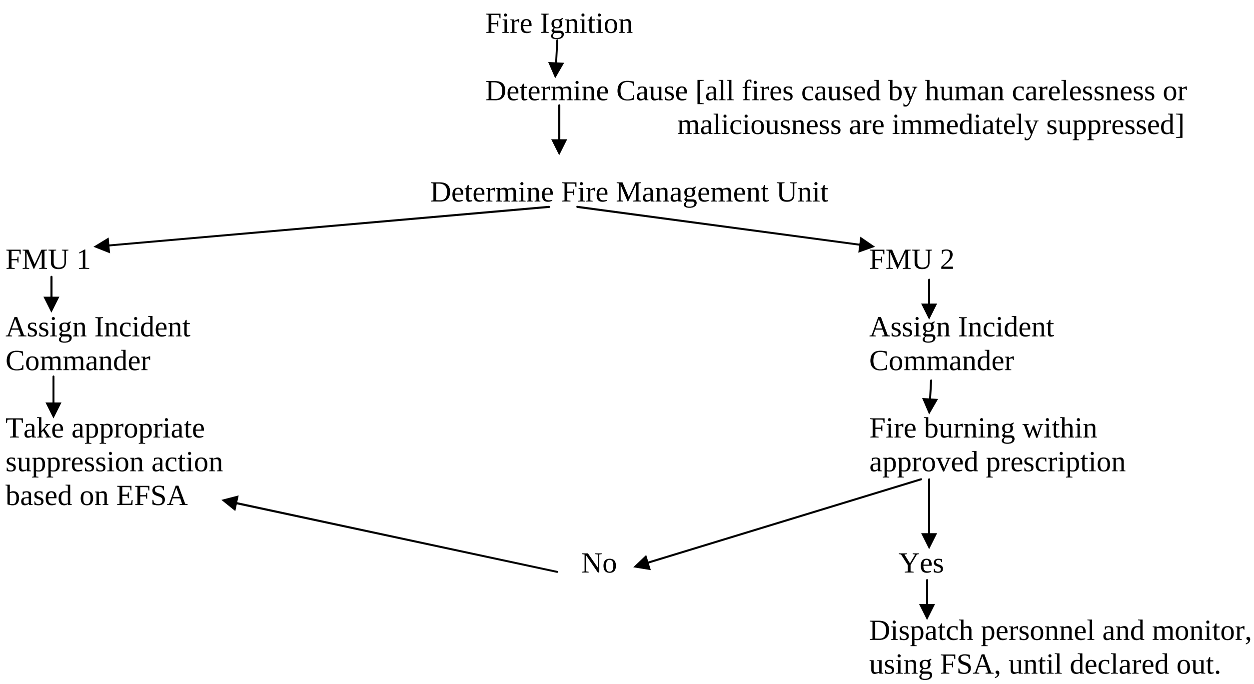
Table II-4: Prescribed burn program 1980-2003.

Name of Burn	Date of Burn	Acres	Vegetation
Tamarisk Piles	Jul-2003	2	exotic
RGV Wetland	Feb-2003	10	riparian
Comanche Draw	Feb-2003	537	desert shrub
Tules	Jun-1999	0.1	riparian
Basin CG	May-1999	9	pinyon-juniper
Lone Mtn.	Apr-1999	645	sotol grassland
PJ Block B	Mar-1999	23	sotol grassland
Bone Spring	Oct-1998	0.2	riparian
PJ Block D	Apr-1998	23	sotol grassland
PJ Block A	Apr-1998	40	sotol grassland
CB Block DEG	Sep-1997	70	pinyon-juniper
PJ Block EF	Jul-1997	52	sotol grassland
Helispot	May-1997	4	sotol grassland
CB Block B	Jan-1996	10	pinyon-juniper
PJ Blk A-90	Jul-1990	5	sotol grassland
San Vicente	May-1988	40	riparian
Basin RX2	Feb-1988	8	pinyon-juniper
Basin RX1	Feb-1988	10	pinyon-juniper
Thistle RX	May-1987	5.5	exotic
Basin RX4	Feb-1987	3	pinyon-juniper
Basin RX3	Jan-1987	2.6	pinyon-juniper
Basin RX2	Jan-1987	5.4	pinyon-juniper
Basin RX1	Jan-1987	5.5	pinyon-juniper
Block B	Apr-1986	1.2	pinyon-juniper
Block A	Apr-1986	0.5	pinyon-juniper
Block C	May-1985	0.1	
Block B	Apr-1985	0.1	
Block A	Apr-1985	0.1	
Basin Burn	Apr-1983	30	pinyon-juniper
Tornillo	Jun-1980	5	Exotic
Plot 4 Boot Canyon	Jun-1980	0.1	Forest
Total Acres		**1539.1 ac**	

Table II-5: Lightning Ignitions 1980-2004

Year	No. fires	Acres burned	Year	No. fires	Acres burned	Year	No. fires	Acres burned
1980	5	3.3	1990	16	214.5	1999	11	29.8
1981	2	680.1	1991	6	1492.1	2000	9	7
1982	4	17	1992	8	2687.1	2001	11	10.5
1983	5	0.9	1993	9	3501.8	2002	19	2.2
1984	3	8.1	1994	13	3876.9	2003	3	0.3
1985	6	439.7	1995	17	86.4	2004	4	0.4
1986	1	6.7	1996	11	15.8			
1987	6	111.5	1997	18	2.7			
1988	9	606.1	1998	6	0.6			
1989	37	5219.5						
							239	**19,021 acres**

Current Decision Flow Chart for Initial Action on Ignitions (FMP 1994)



ESFA: (Escaped fire situation analysis) An analysis of alternative suppression strategies for either confining, containing, or controlling a wildfire.

FSA: (Fire situation analysis) An analysis of alternative strategies for managing a prescribed natural fire for the desired objectives and within prescriptions.

Figure II-4: Decision Tree for Initial Action on Ignitions. Alternative A

Alternative B: Full Wildland Fire Use

Purpose

This alternative was developed as an option to quickly reintroduce fire into the park. Both prescribed fire and wildland fire will be used to (1) reduce fuel loadings in all vegetation types that are at risk of high-intensity and high-severity fire, and (2) move ecosystems towards dynamic states by controlling shrubs, maintaining grasslands, reducing fuels or renewing plant communities. Allowing more fire stems from confidence that low and moderate-intensity prescribed burns and natural ignitions (wildland fires) are needed, and that, possible long-term negative effects can be tolerated even though desired vegetation conditions are not well documented. Effects following fires would be monitored to build knowledge particularly of fire in the Chisos. Vegetation and fuels would be assessed in the Chisos to identify areas where natural fire can burn safely either after prescribed burns or without prescribed burns. In the event of natural wildland fires where visitor safety was not an issue, fire would be allowed to burn at low and moderate intensities, initiating the return of historical fire regimes. The main differences between this Alternative and Alternative C is this alternative has no requirement for post-fire monitoring of prescribed burns, nor requires that research results on fire effects and fire dynamics guide the introduction of fire in the Chisos. Reduction of fuels is expected to be much quicker over a wider area than under Alternative A.

Organization

Alternative B has two FMUs, as shown in Figure II-5. FMU 1 includes developments, fire-sensitive cultural resource sites, legally protected species and 1-mile buffer along park boundaries where fire must be suppressed. Agreements are being negotiated with neighboring agencies and large landowners to shrink the buffer to a variable limit that allows fire to burn to natural or manageable boundaries such as the river, roads, bare areas, and cliffs both in the park and beyond. The expected benefits include more cost-effective use of fire management resources, safer fire management practices, and less damage to soils and vegetation from suppression activities. FMU 2 includes the rest of the park.

Expected Outcomes
This alternative offers fuel reduction more quickly than Alternative A or C and may be more effective at preventing widespread fire in the Chisos under extreme conditions. The IDT felt that since historical fire intensities and regimes are not well documented it is conceivable that stand-replacing fire could have occurred in the Chisos prior to European settlement. Fire intolerant species in mesic areas would develop between such fires. Despite the benefits from rapid fuel reduction, the IDT questioned risk to public values, unknown fire effects in particular species and habitats, fire dynamics in high fuel situations, the difficulty of managing fire in rugged terrain under low and moderate fire intensities (required under prescriptions), and the possibility that exotic plant species, now widespread in the park, may colonize bare areas following fire. They concluded that this was a hard-to-safely-implement alternative.

Prescriptions
The decision criteria for allowing fire under Alternative B are more flexible than Alternative A and are illustrated in II-6. Variables for estimating fire effects have changed since 1994 and a direct comparison with measures used at that time is not possible. However, the current variables when combined create a more comprehensive measuring stick than was used previously. The more liberal prescriptions proposed are derived from staff experience with fire over the past 10 years within the park and from fire use in comparable areas. Major changes include:

- Not assigning a prohibitory wind speed in areas where fuels are low and widespread fire is highly unlikely;
- Assigning an upper limit of FDFM (Fine Dead Fuel Moisture) to ensure that research fires in the Chisos will burn under low to moderate intensities;
- Assigning a lower limit to LFM (Live Fuel Moisture) that will protect mature trees especially in the Chisos;
- Increasing the upper limit of the LFM to ensure management ignited fires burn and the benefits outweigh the costs; and,
- MFWS (Mid-Flame Wind Speed) is set to ensure spread is slow or limited where preservation of resources is desired.

Should natural fires occur outside prescriptions they will be monitored closely and either suppressed, or allowed to extinguish naturally where natural barriers to fire exist. Overall these prescriptions together with more liberal initial decision-making criteria provide more flexible tools for allowing burns for management purposes. Suppression actions for Alternative B are the same as for all alternatives. Non-fire treatments are the same as Alternative A.

Mitigative Measures
Mitigative measures for cultural and natural resources are outlined in "Elements Common to All Alternatives." Proposing more fire in the park will require explanation to the visiting public. Three to four generations of Texans heard Smokey Bear say "no fires" in the forests, and on the range as well. Widespread, high-intensity fires throughout the West in recent years reinforces the notion that fires create "bads' when they burn and no "goods." The more complex story of fire in ecosystems will require frequent and convincing messages by park staff and scientists. Understanding the complexity of fire effects make interpretative activities a high priority for park staff. Helping the public understand the process of fire planning has begun with a series of explanatory posters currently at Sul Ross University.

They will be moved to sites within the park when space is available. Interpretative staff intend including an educational column on the park web site and in local papers, and to develop displays and written materials to assist interpretative efforts.

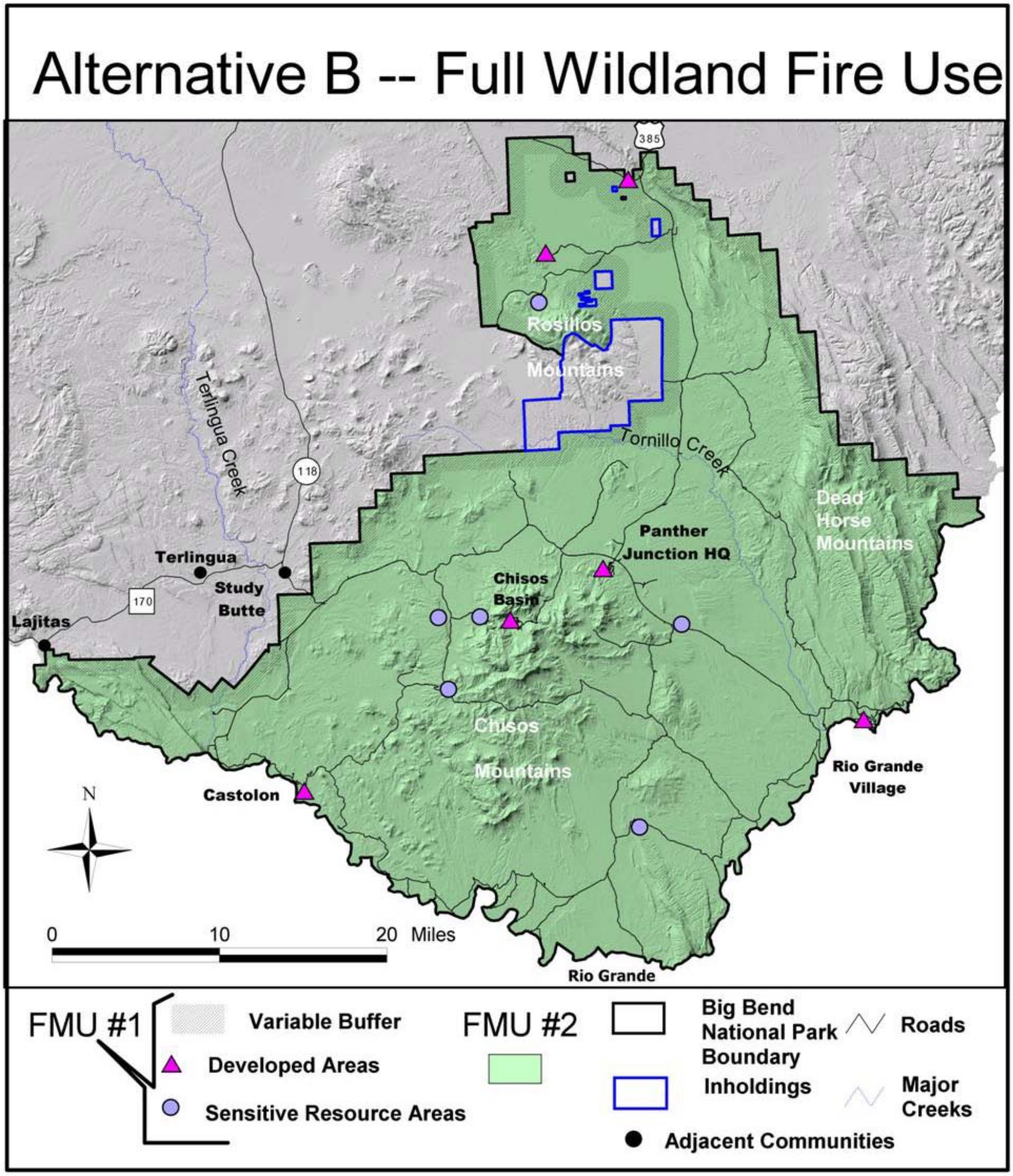


Figure II-5: Alternative B: Full Wildland Fire Use

I. Proposed Decision Flow Chart for Initial Action on Ignitions (New FMP)

Fire Ignition

Determine cause

Unplanned human caused

Suppress immediately

Natural ignition

FMU 1

Suppress

FMU 2

See chart below

- Must answer YES to all criteria to reach a GO decision.
- Any NO answers result in a NO-GO decision and declaration of a wildfire. Once declared, the fire cannot be reverted to wildland fire use.

Figure II-6: Decision Tree for Initial Action on Ignitions for Alternative B & C

Decision Criteria (FMU 2)	Questions
Ignition	Is it a natural source?
	Is the location within a wildland fire use zone? *Or*, Can the natural ignition meet research requirements under Research Burns? [Fire use decisions depends on meeting location, values-at-risk, season, and desired outcomes criteria]
Management Objectives	Are resource objectives being met? Are potential effects on natural and cultural resources within the acceptable range of effects and variability?
Size	Is the current and expected size known?
	Is the potential risk for escape acceptable?
Fuels	Are live fuels moistures within prescription?
Weather	Are drought indicators acceptable (1000-hr TLFM*, Palmer drought index)
Topography	Is the terrain in locations for potential holding actions along the maximum management area accessible and safe for crews to work in?
Resource Availability	Are local, regional or national resources available?
Safety of Life and Property	Can the threats to firefighters, staff, visitors, residents, neighbors, associated property and infrastructure be minimized?
Environmental Constraints	Is smoke dispersal and direction acceptable?
Political Constraints	Is managing this fire for wildland fire use compliant with current policy, moratoriums, political constraints, funding and efficiency issues?
Summary	If YES to all above – manage within prescriptions

TLFM* = Time-lag fuel moisture. 1000-hour TLFM is a measure of moisture content of the largest diameter fuels.

Table II-6: Prescriptions for Prescribed and Wildland Fire Use For Alternative (B)

	Vegetation Types and Fuel Models					
Parameters	Flood Plain (3 & 8)	Scrub Desert (1)	High Desert Grasslands (2)	Shrub Woodland (6)	Grassy Woodlands (2)	Forest (10)
Fire Management Unit	1 & 2	2	2	2	2	2
Fine Dead Fuel Moisture (fuel particles <0.25" in size and measured in % of moisture)	Unlimited in non developed areas > 5% in developed areas	Unlimited in non developed areas > 5% in developed areas	> 5%	> 5%	> 5%	> 5%
MFWS (mph)	Unlimited in non developed areas < 8 mph in developed areas	Unlimited in non developed areas < 8 mph in developed areas	0 to 8	0 to 8	0 to 8	0 to 8
Live Fuel Moisture (%)	n/a	n/a	>100	n/a	>100%	>100%
Slope (%)	n/a	n/a	n/a	>25% ONLY in secure locations	>25% ONLY in secure locations	>25% ONLY in secure locations

Legend*:* (Attributes taken from Fire Behavior Field Reference Guide)

- **Fine Dead Fuel Moisture (FDFM):** This relates to grasses and other fine texture or small particle fuels. The measurement considers temperature, relative humidity, time of day, aspect, slope, shading (from overstory or clouds), and season (winter, spring, summer, fall). Measurements range from 2 to 20%. The higher percentages indicate wetter fuel. From experience at Big Bend, FDFM reaching 5% has been a trigger for sustained fire spread in our patchy grassland fuels.

- **Mid Flame Wind Speed (MFWS):** MFWS is the average velocity of wind measured at eye level. This can be read directly with a handheld anemometer or calculated from weather station wind speed measurements (at 20 ft and average over 5 minutes) with the consideration of the sheltering effect from vegetation or topography. From experience at Big Bend, fires will spread in the grasslands if mid flame wind speed is > 8 mph. If less than 8 mph, fires tend to not spread on flat ground.

- **Live Fuel Moisture (LFM):** LFM is related to the stage of vegetative growth and moisture content of live vegetation. LFM may range from a high of 300% for fresh, moist foliage early in spring to 30% for completely cured foliage. The 100% live fuel moisture rating is considered mature foliage with new growth complete, comparable to older perennial foliage. From experience at Big Bend, 100% LFM has been sufficient moisture content to protect mature trees from fire related injury during moderate fire behavior conditions. During the Casa Grande Fire of 1999, LFM was recorded ranging from 65-85% and mature trees were killed under higher intensity fire behavior conditions. Where LFM is not a crucial factor in predicting fire behavior in certain fuel models, it is listed as n/a.

- **Slope and Secure locations**: This relates to the steepness of the topography. A rating of "n/a" means to allow burning on all slopes in these vegetation types. At higher elevations and woody vegetation, prescribed and natural ignitions are allowed on slopes > 25% only if the fire spread is a backing fire (backing down hill, against the slope) or the fire spread will likely stop against fire spread barriers (talus slopes, cliffs, and other secure locations). From experience at Big Bend, slope steepness has not been a strong factor in fire behavior predictions.

Fuel Models (derived from Anderson, 1982)

1 = Fire spread is governed by fine, porous and continuous herbaceous fuels that are almost cured. Typical of grasslands and grass-shrub assemblages. High rates of spread are possible. This model predicts fire behavior in Scrub Desert vegetation, although it has very patchy fuels.

2 = Fire spread is from fine cured herbaceous fuels in addition to litter and downed stem wood. Open shrublands, scrub oak and some juniper-pine assemblages fit this model. May produce intense fires. This model fits High Desert Grasslands and Grassy Woodlands, although the dead fuel loadings are lighter than the model's average.

3 = Fire is carried through tall grasses where one-third or more are considered cured or dead. Highest intensity of the grass fires, especially under wind. Giantreed stands along the river fit this model.

6 = Fire carries through the shrub layer at moderate wind speeds (8mi/hr) but drops to the ground at lower speeds and at breaks in the canopy. Shrub woodlands found in lower mountain drainages.

8 = Slow-burning ground fires with low flame lengths. The fire supporting layer is composed of compact leaf litter, needles, leaves and twigs. Tamarisk and Mesquite thickets along the river.

10 =In addition to leaf litter there are up to 3 tons per acre of downed dead material. Fires can be intense burning at ground and canopy level and be difficult to control. This model is characteristic of the forest vegetation category.

Alternative C: Progressive Wildland Fire Use

Purpose

Concerns about possible outcomes from Alternative B's more liberal fire use led to the development of Progressive Wildland Fire Use or Alternative C. Consideration of Alternative B led to the following observations: (1) burning without identifying fire effects in sensitive habitats involves considerable risks to park resources and values; (2) adherence to a particular management trajectory without a supporting research program could result in significant negative impacts on the vegetation over the long-term; (3) research burns would assist staff understand how to safely reintroduce fire in particular habitats, provide local, species specific, as well as long-term and ecosystem wide information, which together with; (4) adaptive management processes - learning and reflecting on results on a regular basis -will help prevent negative unintended consequences. These observations led to the proposal of a research platform guiding Alternative C, and considering the Chisos a Special Treatment Zone under this FMP.

Organization
There are two FMUs under Alternative C and a Special Treatment Zone. The inclusions and treatments for FMU 1 are the same as Alternative B. FMU 2 covers the rest of the park allowing wildland fire to burn where park resources, unique habitats, threatened species and infrastructure are not at risk. Prescriptions and decision criteria are the same as for Alternative B.

The IDT designated the Chisos a Special Treatment Zone within FMU 2. Wildland fire will be permitted within prescriptions and monitored very closely. Prescribed burns will be used to answer research questions, protect developments and support the protection of federally listed species. Data will be collected identifying species-specific responses to fire, fire dynamics under differing fire intensities, and high fuel loads. Burns will be small, include multiple repeat treatments, be no more than 10% of any habitat, require pre and post-fire monitoring, include analysis and evaluation, and require incorporation into management discussions and decision-making. Information from research burns will guide the introduction of fire particularly into the forest and woodlands of the Chisos. Fire will be excluded from a Research Natural Area in upper Pine Canyon, above the campsites and the end of the road. This area has not experienced fire in many decades and will serve as a reference site in the event of future fire. Research fires will also be conducted in other areas of the park to meet resource objectives such as grasslands restoration, protecting or enhancing habitat of listed species, and developing control strategies for exotic species.

Research Approach
Fire researchers have refined prescriptions to manage for the severity of fire under normal weather conditions. What is less well known is the outcome of fires at varying intensities on particular species, and habitats. Staff are seeking ways to protect valued resources including the mature trees in the Chisos, relict species, endemics and unique habitats. National fire-return intervals are a guide to maintaining normal fuel levels and condition class I-II. These guidelines are averages and formulated to cover a range of environmental variables. Big Bend staff want fire intervals that reflect local conditions. They believe that continuing the efforts of fire researchers began in the late ‘70s and early ‘80s, who established plots in Boot Canyon, SE Rim, Laguna Meadow and on the slopes of Emory Peak will lead to knowledge about fire return intervals and how to introduce fire into the Chisos safely. Just one plot (of Arizona Cypress) was burned in Boot Canyon and only 1 year of data collected. Multiple years of data are needed to indicate mortality, guide the refinement of prescriptions and indicate trends, helping make more informed decisions about appropriate fire frequencies for the park’s vegetation types. The research approach and initial reference base follow in text boxes.

Expected Outcomes
Increasingly natural resource managers are being asked to manage vegetation to objective and measurable outcomes. The park has limited research to support this knowledge-based approach, and is cautious about accounting for multiple interactions among environmental variables. Clear, objective, and measurable outcomes implies that managers understand how periodic perturbations such as fire, suppression, grazing, logging, and mining affect park plant communities, how the communities have changed over time, and how other larger perturbations caused by climate change, insect attacks, disease, and decreasing air quality are also impacting these vegetation communities. Such knowledge assumes managers know the history of the area, have access to reliable research, and can compare the park to nearby reference sites to understand a range of suggesting the plant communities’ structure and composition. A research program can deepen knowledge to provide appropriate monitoring standards and assist staff ask better questions.

Monitoring associated with research burns also provides a tool to develop knowledge about the approximately 120-130 rare and endemic plant species in the park. So little is known about some of these species that they cannot be protected under the legislation for threatened and endangered species. Knowledge of fire effects on individuals, populations, and surrounding habitat is critically important to the management of these plants. Staff propose that pre-fire and post-fire monitoring of prescribed and research burns take into account the lifecycle of these lesser known species to ensure their protection in the park.

Prescriptions

Prescriptions are outlined in Table II-7 and are similar to Alternative B. They are designed to provide protection for most mature trees. Staff recognize that cycles of burns are required to reduce shrubs encouraging the return of grasses and low-intensity faster surface fires. Staff also recognize the trade-offs of fire managers who must balance the need to create a return on an investment. Prescribed burns take months of preparation from developing burn plans, monitoring, and achieving compliance. They are costly to undertake requiring coordination of many staff and resources. Suppression actions and non-fire treatments for Alternative C are the same as other alternatives.

Fire Ecology Research at Big Bend

The fire ecology program at Big Bend National Park will tailor the fire effects monitoring program to provide pertinent information for adaptive fire management of vegetation at Big Bend National Park. Research burns, by definition, will have a research component, that will include replicated treatments (a minimum of 3 treatment replications) that serve as either “controls” (untreated plots) and plots that receive the experimental treatment of prescribed fire, wildland fire use or mechanical thinning, herbicide application or some combination of treatments (i.e. burning + herbicide). Monitoring will also be conducted on fuels projects that are not designated as research to provide feedback as to whether or not natural, cultural or fire management objectives are being met and provide additional information to adaptively manage both wildland fire use and prescribed fire. First entry fuels treatment(s) into a monitoring type, will be considered research treatment having replicated treatment plots and replicated control plots.

A reasonable attempt will be made to address each of the following Fire ecology research questions in each prescribed fire opportunity (1) effects of fire on plant community composition, (2) effects of fire on rare or sensitive plant and animal species, (3) soil movement, (NOTE: changes in plant composition can be used as a surrogate for soil sterilization (denuded surface) and soil movement =erosion) in response to fire, (4) effects of fire on fuel loading, ladder fuels, and fuel size class distribution, and (5) forest stand age and size class structure. A Fire Effects Monitoring Plan for the Chihuahuan Desert National Park Units (AMIS, BIBE, CAVE, GUMO) will be drafted that will detail monitoring objectives and methods used for research and monitoring to provide scientifically credible data.

Legacy data collected in the past fifty years (e.g. Warnock 1970a,b; Whitson 1965, 1989; Dick-Peddie and Alberico 1977; Meents and Moir 1981, 1982; Wondzell and Ludwig 1983; Dunham 1996; Muldavin et al. 2001) will be used to evaluate ecological trajectories and responses to fire. Whenever possible, existing plots from these studies will be remeasured and the resulting data added to the fire ecology database for the park. Many of these data sets need to be organized, collated, and entered into modern electronic databases to be useful. In addition, many legacy plots will need to be re-located based upon location descriptions in the initial reports. We will accomplish these tasks in advance of the implementation of Research Burns.

These research and monitoring goals will need to be funded by creative combination of resources, including NPS Resource Management funding, FIREPRO, CESU, and other government and NGO sources. Securing funding for adaptive management research is critical to the implementation of the Fire Management Plan.

*Initial Research S*ources:

Dick-Peddie, W.A. and M.S. Alberico. 1977. Fire ecology study of the Chisos Mountains, phase I. CDRI contribution No. 35. BIBE files.

Dunham, A.E. 1996. Long-term ecological monitoring of the U.S.-Mexico borderlands in the Big Bend national Park, TX. BIBE files.

Meents, J.K and Moir, W.H. 1981. Fire Ecology study of the Chisos Mountains, phase II. CDRI contribution No. 17. BIBE files.

Meents, J.K and Moir, W.H. 1982. Fire ecology of desert grasslands in Big Bend National Park. CRDI contribution No. 120. BIBE files.

Muldavin, E., Wondzell, S., and J.A. Ludwig. 2001. Forty years of vegetation change in desert grasslands of Big Bend National Park. BIBE files.

Wondzell, S.M. and J.A. Ludwig. 1983. Plant succession as influenced by soil-geomorphic processes of semi-arid piedmonts of the U.S.-Mexico border. Final Report. BIBE files.

Warnock, B.H. 1970a. Charts, measurement data and examination on selected A& M circular plots. BIBE files.

Warnock, B.H. 1970b. Summary of belt transect data at Big Bend National Park. BIBE files.

Whitson, Paul D. 1965. Phytocoenology of Boot Canyon Woodland, Chisos Mountains, Big Bend National Park, Texas: Permanent Plot Supplement BIBE files.

Whitson, Paul D. 1989. Documentation and analysis of Boot Canyon permanent plots initiated in 1964. BIBE files.

Mitigation Measures

Management responses are similar to Alternative B and include physical rehabilitation of sites, ongoing interpretive efforts with public and neighbors, continuing to build knowledge by mapping endemics, threatened and rare species, identifying containment strategies prior to fire, pre and post monitoring, identifying research questions and design in advance to take advantage of natural fire or for planning for prescribed fire; and pre-fire and post-fire monitoring undertaken at times appropriate for the species or plant communities; and continuing to analyze and incorporate research data into management decisions.

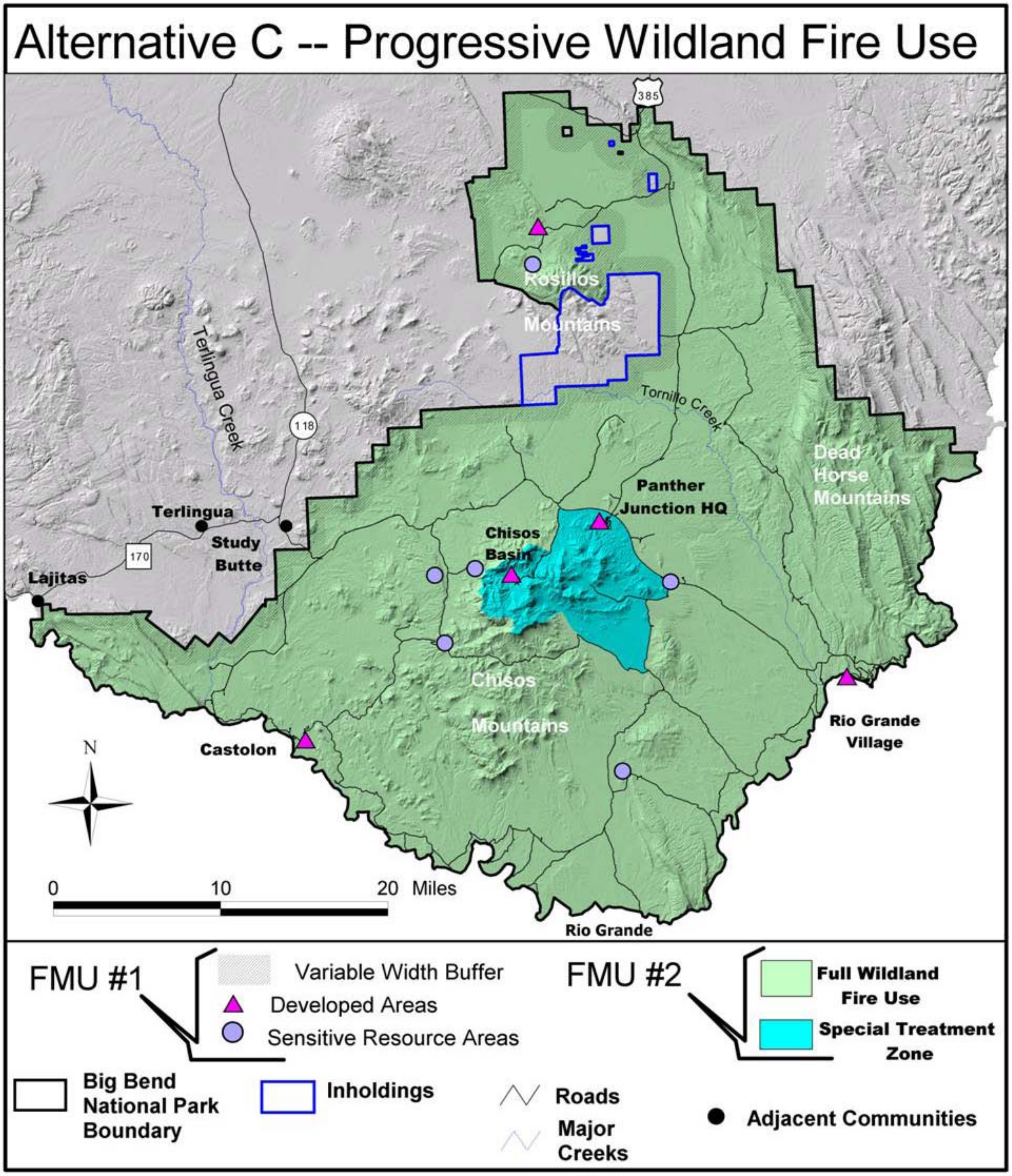


Figure II-7: Alternative C: Progressive Wildland Fire Use

Table II-7: Prescriptions for Alternative C

	Vegetation Types and Fuel Models					
Parameters	Flood Plain (3 & 8)	Scrub Desert (1)	High Desert Grasslands (2)	Shrub Woodland (6)	Grassy Woodlands (2)	Forest (10)
Fire Management Unit	1 & 2, RB	2, RB	2, RB	2, RB	2, RB	2, RB
Fine Dead Fuel Moisture (fuel particles <0.25" in size and measured in % of moisture)	Unlimited in non developed areas > 5% in developed areas	Unlimited in non developed areas > 5% in developed areas	> 5%	> 5%	> 5%	> 5%
MFWS (mph)	Unlimited in non developed areas < 8 mph in developed areas	Unlimited in non developed areas < 8 mph in developed areas	0 to 8	0 to 8	0 to 8	0 to 8
Live Fuel Moisture (%)	n/a	n/a	>100	n/a	>100%	>100%
Slope (%)	n/a	n/a	n/a	>25% ONLY in secure locations	>25% ONLY in secure locations	>25% ONLY in secure locations

The Legend is the same as Table II-6 in Alternative B

*RB = Research burns can be conducted in all FMUs to meet natural or cultural resource objectives. The above parameters are the same as Alternative B except that they are applied to research burns in addition to wildland fire and prescribed burns.

Alternative Eliminated from Further Study

Full Suppression
Concern about (1) safety of visitors, particularly backcountry campers and staff, (2) irreplaceable or fragile cultural and natural resources, (3) value of developments and commerce, and (4) the spread of fire to neighboring properties could dictate a policy of full suppression. This alternative would preclude prescribed and wildland fire use throughout the park. Hazard fuel reduction would be accomplished strictly by non-fire means such as mechanical thinning, mowing, and herbicide treatments to the extent practicable. The difficulty of establishing effective fuel reduction treatments over large enough areas increases the probability that fires may be large with significant impacts.

Reason for dismissal: High-intensity, widespread fires resulting from fuel build up could delay suppression actions, jeopardize the safety of visitors, fire fighters, and staff, and incur very high costs associated with evacuation, suppression, stabilization, and rehabilitation. In addition, it is NPS policy to use fire where it occurs naturally to benefit fire-adapted plant communities reduce fuel loads to safe levels. Under a Full Suppression Alternative resources could be stretched to ensure the safety of visitors, park staff, and firefighters under extreme conditions, and may not be available if conditions or fires in other regions are deemed a higher priority. Staff dismissed the Full Suppression Alternative from further consideration because of negative long-term effects on safety, park values, and natural resource health.

Summary of Reasonable Alternatives

Reasonable alternatives are those that feasibly meet the purpose, need, goals, and objectives of the park. In the short term, Alternative A limits damage to park developments. Over the long term, fuels have, and will continue to buildup jeopardizing park resources. Alternative B will lower fuel levels in the park, and allow fire to return more quickly to Big Bend landscapes. There is no guarantee however, that wildland fires burning at moderate intensities will not significantly change landscapes, views, and resource values for considerable time. In addition it may be difficult to control fire even burning under prescriptions should weather change unexpectedly. Alternative C, like Alternative B, returns fire to the wilderness areas of the park. However, Alternative C also provides a research platform for allowing a gradual introduction of fire into sensitive park ecosystems. Attention to safety, visitor experience, and making decisions based on science promoted the IDT to select Alternative C as the preferred alternative for fire management in the park. The uncertain nature of fire and weather mean that while every effort is made to reduce risks, there is no guarantee that large fires will not occur while scientists and managers determine the best approaches to reintroducing fire across the park.

Table II-5 summarizes important features of each retained alternative described above and the effectiveness of these alternatives in meeting the FMP purpose, need, goals, and objectives. Table II-5 reviews impacts of alternatives over the eight impact topic areas staff determined the FMP must address. Each of the retained alternatives contains a different mixture of the same elements: suppression, prescribed fire, wildland fire use, and non-fire fuels treatments for resource benefit. There is no way to specify exactly how much of each strategy would apply if any one of the alternatives were selected, because the "amount" of each fire form depends on weather, administrative contingencies, and chance ignitions.

Environmentally Preferred Alternative (NEPA Sections 101 and 102)

The goals characterizing the environmentally preferable condition are described in Section 101 of the National Environmental Policy Act (NEPA). NEPA Section 101 states that "….it is the continuing responsibility of the Federal Government to … (1) fulfill the responsibilities of each generation as trustee of the environment for succeeding generations; (2) assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings; (3) attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences; (4) preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity, and variety of individual choice; (5) achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and (6) enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources."

Alternative A allows the least amount of fire on the landscape. Fuels to continue to buildup increasing the risk of high-intensity, widespread, and stand-replacing fires. The consequences of such fires are likely to cause adverse long-term effects to natural resources and potentially permanent effects to historic and cultural resources, negatively impacting all of the NEPA criteria listed above.

Alternative B allows more fire at higher intensities on the landscape than the other Alternatives and while quickly moving the park to receiving natural ignitions, the short-term effects may be negative and greater than public opinion would tolerate. Cultural resources, natural resources, and aesthetically pleasing environments are most at risk under Alternative B while recycling of renewable resources is most enhanced under this Alternative.

Using the goals above, Alternative C is the environmentally preferred alternative. Actions proposed under Alternative C are those most likely to safely provide the foundation for ensuring landscape and ecosystem health over the long-term without undue adverse effects to aesthetics, resource use, and historic, and cultural resources. Cultural resources including historic sites will be protected as for Alternative B. Valued natural resources will undergo renewal however, based on the results of research burns. Alternative C best meets conditions (1) though (5), with condition (6) best met by Alternative B.

The Progressive Fire Use designation acknowledges that uncertainty exists about how to safely allow fire to assume its natural role in the Chisos while protecting valued ecological resources and views. Park staff proposed small burns to gather data, repeat treatments, and then apply results in the Chisos Mountains as a method for developing their management trajectory for this area. This alternative accommodates concerns about safety, the needs of visitors, a scientific approach to reintroducing fire, and maintaining resources for the long-term. Thus, Progressive Wildland Fire Use becomes Big Bend National Park's proposed preferred alternative and environmentally preferred alternative.

Table II-8: Major Characteristics of Fire Management Alternatives

Characteristics	Alternative A: No Action	Alternative B: Full Wildland Fire Use	Alternative C: Progressive Wildland Fire Use
1. Management direction	Prescribed fires reduce fuels around developments. Suppression elsewhere minimizes short-term risks to property and resources. Long-term risks increase with fuel buildup.	Prescribed fires around developments, cultural resources, sensitive habitats. Wildland fires considered natural and needed. Allow low to moderate intensity fire where safe. Accept risk of short and long-term effects due to fuel buildup.	Prescribed burns as for Alternative B. Acknowledges uncertainty about how to allow fire to resume its role, especially in the Chisos. Adaptively manage wildland fire with data from research burns (RB).
2. Wildland fire use	Current decision criteria have greatly limited wildland fire use.	Allow low and medium intensity wildland fires to burn within prescriptions.	Same as Alternative B.
3. Suppression of wildland fires *	Most wildland fires suppressed based on strict criteria that govern decisions following ignitions.	Suppress around infrastructure and cultural resources; limit suppression as risks from fuels are reduced.	Suppress around infrastructure and cultural resources; possibly less suppression as fire effects understood.
4. Prescribed burning program	Burn around infrastructure to reduce fuels.	Burn around infrastructure, cultural resources and elsewhere in the park to allow safer wildland fire use and achieve resource benefits.	Burns around infrastructure and cultural resources to reduce fuels and RB to collect knowledge of fire effects. Requires pre and post-fire monitoring.
5. Fuel reduction	In all FMUs.	Same as Alternative A.	Same as Alternative A.
6.Planning	Current planning is adequate.	Survey fuel loads, identify where wildland fire can burn safely for resource benefits, and where prescribed burns or other treatments are needed to precede wildland fire.	As for Alternative B. In addition, identify questions to be answered by research burns. Long-term funding for pre-fire, post-fire of research burns, to record and assess fire effects.
7.Staffing levels	Use existing staff.	Add and train staff to manage expanded prescribed and wildland fire use. Additional coordination and interpretation requires additional time, cost and resources.	Similar to Alternative B. In addition, staff with specialized expertise are needed to conduct or assist with research burns in sensitive habitats.
8. Cooperative agreements with park neighbors	Suppress fire within 1 mile of park boundaries. Honor existing agreements with neighbors. Continue suppression rather than broader, long-term safety, or ecosystem health.	With neighboring landowner's permission, allow fire to be contained at natural boundaries such as river, cliffs or roads. Increase outreach to local and broader publics on resource and safety benefits of flexible boundary agreements.	Same as Alternative B.
9.Fire-effects monitoring	Maintain current levels of monitoring.	Increase post-fire monitoring of larger areas as more wildland fire use is allowed.	Requires most monitoring; detailed pre-fire and post-fire monitoring of research burns; post-fire monitoring of natural ignitions.

Table II-9: Effectiveness of Alternatives in Meeting Goals and Objectives

	Alternative A No Action	Alternative B Full Wildland Fire Use	Alternative C (Preferred) Progressive Wildland Fire Use
Major Features	FMU 1: Effective use of prescribed burning and non-fire treatments to reduce fuels around developments. FMU 2: Not effective in reducing fuels or allowing ecosystem processes. Initial wildland fire use decision criteria (go/ no-go) results primarily in suppression.	FMU 1: Same as No Action. FMU 2: Most effective in allowing more fire on the landscape. Allows most fire; extends fire to natural barriers along park border using pre-determined agreements with neighbors. There is confidence that fire effects will not cause adverse effects longer-term even if these effects are unknown. Fire effects will be monitored.	FMU 1: Same as No Action. FMU 2: Similar to Alternative B but benefits achieved over longer-time frame. Special care in Chisos. Staff learn of fire effects through research burns providing greater protection for unique habitats, cultural resources, rare and threatened species.
Goals & Objectives			
1. Protect life and property	FMU 1: Effective in reducing fuels around infrastructure. FMU 2: Suppression and subsequent fuel accumulation elsewhere in the park increase the long-term risk of high-intensity, widespread fire.	FMU 1: Same as No Action FMU 2: Effective. Increases risk to firefighters and property in the short term with more, larger, and hotter fires. Reduces hazardous fuels long-term.	FMU 1: Same as No Action. FMU 2: Effective over a longer time frame than (B). Research burns builds knowledge to allow wildland fires in the longer-term.
2. Reintroduce fire to accomplish natural resource goals.	Least effective. Suppression is the usual outcome for most wildland fires in park.	Effective. Fire can burn across much of the park. However, fuel loads in the Chisos may result in long-term negative effects.	Effective. Incrementally reintroduces wildland fires and builds knowledge about fire effects on natural resources.
3. Apply fire to meet cultural resource goals.	Not effective. Most fires suppressed leading to buildup of fuels.	Effective. Reduces fuels across the park and reduces risk longer-term. Assessment of sites required to determine risk and treatments.	Similar to Alternative B. Most effective. Offers greatest flexibility in meeting cultural resource goals in the short and long term. Research burns may provide clues to protecting cultural resources.
4. Minimize unacceptable environmental impacts to cultural and natural resources.	Tight prescriptions have not controlled all fires. Fuels continue to increase as does the probability of high-intensity, widespread fire in the Chisos.	Somewhat effective. Less restrictive go/no-go decision criteria enables a range of responses to risk. Post-fire monitoring builds knowledge of fire effects.	Most effective. Similar to Alternative B but monitoring is pre and post-fire. Builds better knowledge of fire effects for longer-range natural resource decisions and protection of cultural resources.
5. Manage fire	Effective in meeting legal and	Effective. New agreements allow variable	Same as Alternative B. Monitoring results

	Alternative A No Action	Alternative B Full Wildland Fire Use	Alternative C (Preferred) Progressive Wildland Fire Use
cooperatively with neighboring agencies and landowners.	political agreements. Existing agreements with Mexico and the state of Texas require suppression within one mile of park borders without considering terrain or vegetation. No incentive to improve safety, cost effectiveness or natural resource outcomes.	boundaries based on natural features improving safety, making better use of fire-fighting resources, with landscape and ecosystem wide benefits. Fuels will be reduced over time with more wildland fire. Neighbors can share ownership of park successes.	from research burns may lead to greater interest by neighbors in cooperative management of natural resources.
6. Coordinate fire activities within all park divisions, with concessionaires and the public.	Successful communication is dependent on administrative actions and follow-up within the park.	Same as Alternative A.	Same as Alternative A.

Table II-10: Impact Summary

Overview	**Alternative A** **No Action**	**Alternative B** **Full Wildland Fire Use**	**Alternative C** **Progressive Fire Use**
1. Life and Property: *Issues*- Fire is an effective tool for reducing hazard fuels, but it is also a threat to the public, firefighters, park staff, and developed areas. *Plan overview* – Safety is the highest consideration. The fire management plan dictates actions when life and property are threatened. Agreements with agencies and neighbors can improve safety, cost-effectiveness and reduce damage to natural resources.			
• Create safety: reduce fuels; safe egress is needed from the Basin. • Cooperative agreements can improve safety, reduce firefighting costs, and provide natural resource benefits. • Agreements also create a greater need for collaboration, education, and shared policies to managing fire.	Long-term minor to moderate adverse impacts to life and property from by allowing fuels to increase. Suppression of fire under extreme conditions in rugged terrain poses direct, moderate to major adverse risks to firefighters, hikers and visitors in the Chisos Basin. Fire occurrence and history of effects is limited but no impairment has occurred to date from fire.	This alternative may expose firefighters to more fire and risk than other alternatives. While firefighters and the public may initially be exposed to greater risks; adverse impacts ranging from minor to moderate intensity over the short-term; these risks decline as fuels are reduced providing minor to moderate long-term benefits. Alternately, more exposure to fighting fire increases staff expertise leading to long-term moderate beneficial effects on life and property.	More burning builds a skill base; research builds a database with potential to provide long-term moderate to major beneficial effects on life and property. Conducting research burns would involve short-term minor to moderate direct adverse risks. Activities associated with research burns improve the skill base in the park and provide a platform for adaptive management, a long-term moderate to major beneficial effect in reducing risk to life and property.
2. Visitor Experiences: *Issues*-Burning areas, closed roads and smoke may deter visitors, but the fire program also provides opportunities to show how fires are essential to natural processes. *Plan overview* –More prescribed and natural fire will reduce the likelihood of destructive high-severity fire. Communication will be increased throughout the park and area to limit inconvenience from fire, and increase interpretive opportunities.			
• Negative perceptions of fire exist when humans are inconvenienced. • Interpretation helps humans think long-term about ecosystems.	Suppression retains the status quo. Prescribed burns occur outside peak visitation times minimizing disruption. Over the long-term Alternative A increases the probability of, high-severity fire in the Chisos. Suppression of such a fire would create direct and indirect long-term adverse impacts to visitor resources and park aesthetics.	More wildland fire would result in greater direct short-term minor to moderate adverse impacts to visitors as they experience road closures, smoke and limited access to the park. Reduction of fuels in the Chisos minimizes the threat of high-severity fire. Greater interpretive efforts by park staff would provide long-term indirect beneficial effects as visitors support policies that encourage natural fire regimes in park ecosystems.	Effects of Alternative C are beneficial and minor over the short-term. Scientific evaluation of research burns applied to fire policy and interpreted for the public, provide a touchstone enabling visitors to weigh immediate direct adverse effects with potential long-term beneficial effects on ecosystems. Benefits to visitors are expected to be greatest under this alternative.
3. Local Economy: *Issues*- Fires may dissuade visitors or attract them. Local merchants and firefighters benefit from fire operations but may also lose patronage if visitors choose alternate destinations. *Plan overview* – More routine fire events provide income on a regular basis. Fire events can be used as opportunities for interpretation.			

• Fire activities are important income for this area. • Merchants, firefighters in Texas and Mexico benefit. Visitors may be attracted or repelled by fire activities.	Minimal disruption improves gains from visitors. A high-severity fire would giver merchants and firefighters a one-time windfall. Visitors may go to a greener place.	Alternative B would result in short to long-term beneficial effects to seasonal firefighters and local merchants as fire frequency increases in the park. Benefits are expected outside fire season for prescribed burns and during fire season for natural ignitions, extending the period of benefits to firefighters and merchants.	Under Alternative C beneficial impacts to the economy would range from minor to moderate depending on fire frequency, duration, intensity and size, and whether permanent park staff can meet staffing and additional seasonal firefighter needs.
4. Vegetation: *Issues*-Fire occurs in many plant communities stimulating diversity, thinning and regeneration; large-scale fire retains the mosaic pattern of vegetation. Suppression has increased fuels and the likelihood of damage from high-severity fire. Fire is an integral part of wilderness-an area also favored by park visitors. Exotics respond more vigorously than many natives to fire and may displace them. *Plan overview* –Allowing natural and prescribed fire at low and moderate intensities reduces fuels and provides greater control over fire timing, location and effects limiting threat of large-scale fires. Interpretive actions warn visitors of the dangers of wilderness under extreme weather conditions and an evacuation plan exists for the Basin. Fire is being considered as part of a sequence for controlling exotics especially saltcedar, buffelgrass, and Bermuda grass.			
• Fire adapted plant communities benefit from fire and enhance habitat for wildlife. • Unique habitats - all respond differently to fire. • Research fires will be small. • Fire is an integral part of wilderness Suppressing fires in wilderness is costly. Risks to visitors will increase with increasing fuel loads. • The effectiveness of fire as a management tool for exotics varies by plant species.	Beneficial direct short-term impacts for protecting habitats, wildernessr. High severity fire in the Chisos leads to moderate to major adverse impacts over the short-term. Long-term the effects are unknown but no impairment.	Minor adverse short-term impacts from fire with moderately long-term beneficial effects to vegetation communities and fuel levels as natural fire regimes are restored. Applying mitigation measures to burned areas of exotics provides short-term beneficial effects.	Short-term adverse minor to moderate impacts are expected from vegetation loss with direct long-term beneficial effects to improving diversity in plant species and community structure.
5. Threatened and Endangered Species: *Issues* – Fire can injure or kill rare species but may also aid in the recovery of others. *Plan overview* – Sensitive prescriptions and conservation measures will reduce fuels providing greater protection for listed species except under extreme fire conditions.			
• The park contains many rare, endemic, threatened or endangered species. • Some habitats experienced more fire in the past.	Efects to plant and animal species are minimized by suppression-adverse effects over time as fes are likely to be more widespread and burn hotter. Removal of habitat is likely to cause greater loss than direct impacts of fire to animal species.	Mre low and moderate intensity wildland fire and additional prescribed burns lessens fuels and the likelihood of adverse effects to plant and animal species and habitat from high-severity fire. These are indirect long-term minor to moderate and beneficial.	Reduction of fuels across the park reduces fire intensity – a direct minor beneficial effect. Applying research results to manage habitats of protected species is a long-term direct beneficial effect.

6. Cultural Resources: *Issues* –Historic structures, landscapes and artifacts may incur fire damage. *Plan overview* –Prescribed burning and mechanical thinning will reduce fuel buildup near structures and sites. Fire will be kept away from the most sensitive sites.			
• Historic structures contain burnable materials. Reduce fuels around CR sites. • Cultural landscapes may be defined by particular plants which need protecting or replacing following fire. • Fire may also help reduce surrounding hazard fuels and maintain the historic scene.	Suppression protects sites creating minor to moderate beneficial impacts. Impacts are likely to be localized and long-term.	Alternative B is likely to result in long-term beneficial effects as fuels are reduced across the park and treatments of specific sites are implemented. Effects on unknown sites cannot be easily determined but prehistoric sites that have burned previously likely will not be damaged further. Greatest risks are from suppression activities.	Implementing mitigative measures in conjunction with increased fire use in the park would keep minor adverse long-term impacts to a minimum.
7. Watershed effects: *Issues*- Fire can remove vegetation, burn organic matter leaving soils open to erosion until plants regrow. *Plan overview* – Allow natural ignitions to burn at low and moderate intensities limiting damage to mature trees. Research burns will identify fire dynamics and effects in particular habitats and fuel situations.			
• Fire can remove vegetation from slopes and cause increased erosion until plants regrow. • Intense rains on steep, bare slopes after fire may lead to debris flows. • Rare plant and animal species in drainages may be killed by debris flows.	Fire management suppression impacts to watersheds in the Chisos are likely to be adverse, minor to moderate and long-term while suppression continues. The potential continues for moderate, adverse impacts to soil stability and debris flows following high-severity fire and summer monsoons. While suppression remains successful impairment is unlikely. Minor, adverse impacts are expected to watersheds in lowland deserts.	Under Alternative B adverse impacts to the Chisos Mountain watersheds would be minor to moderate and short-term. Minor adverse impacts from fire are likely in lowland desert areas. Beneficial impacts are expected over the long-term for watersheds in the Chisos. Extreme fire events outside prescription before fuels can be reduced would create moderate to major direct adverse impacts over the short and long-term.	The preferred alternative would result in long-term moderate direct and indirect beneficial effects. Low to moderate intensity research burns, assessment of fire effects and gradual reintroduction of natural ignitions based on this knowledge is expected to safely reduce fuels and preserve resources. Fire management guided by research into restoration of lowland deserts may have direct and indirect benefits to watersheds over the long-term.
8. Resources for the Fire Program: *Issues*-Moving from a suppression-oriented fire program to more prescribed and fire use will require additional resources. *Plan overview* – The fire program is considering the staff, training and equipment needs to allow the preferred alternative to be implemented successfully.			

• The availability of skilled seasonal or permanent staff and equipment determines whether fire program activities can be planned and implemented. • The current fire program focuses on reducing fuels around developments. Action alternatives require extra resources for more prescribed burning, wildland fire management etc.	Under the current management direction there would be long-term minor to major adverse impacts to park values and resources as existing staff are called to meet increasing numbers of emergency fire situations.	Under Alternative B, more frequent and larger natural fires, and more fuels reduction treatments are expected to tax existing staff, seasonal firefighters, engines, and equipment. Shifting from suppression under Alternative A to more routine fire events will require reassignment of staff priorities and/or hiring of additional staff with sufficient engines, equipment and safety training. Depending on how resource needs are met, these changes could be minor to moderate adverse (if met within the park) or beneficial (additional hires from outside the park) with direct and indirect long-term effects to park resources.	Under Alternative C, impacts to resources for the current fire program and staffing levels are likely to result in moderate direct and indirect adverse effects. The expected increase in actions cannot be met without additional input from scientists for research burns, cultural resource specialists for protection of specific sites, knowledge of fire effects across the park (requiring pre-monitoring and post-monitoring (whenever possible)), and additional permanent or seasonal staff. These requirements are likely to instigate long-term changes in the park fire policy to enable adaptive management of resources and values.

Chapter III : Affected Environment

This chapter provides information about the park necessary for understanding the effects of the fire management alternatives analyzed in Chapter IV. Appendix D lists the scientific names for plant and animal species mentioned throughout the text.

Impact Topic (1): Life and Property.

Big Bend National Park is located Brewster and Presidio rural counties in the prominent southward bend of the Rio Grande River. The mid-channel of the 118 miles of river bordering the park also forms the international boundary with Mexico. Two large preserves in Mexico, Maderas del Carmen and Canyon de Santa Elena enlarge the protected area of the park, and allow movement of species that do not respect human imposed property lines including domesticated livestock. One mile from the southwestern border is the Big Bend State Ranch Park and to the northeast the Black Gap Wildlife Management Preserve. Ranches and ranchettes abut the northern and northwestern boundaries of the park. Many are absentee landowners making cooperative fire management challenging. Gateway communities are slowly growing, attracting retirees and businesses that provide for visitors and these service centers need to be kept abreast of park developments. Several right of ways and service utility easements cross the park.

There are three main developments providing services to visitors within the park. The Chisos Basin, Rio Grande Village, and Panther Junction provide interpretive facilities, lodging in rooms, campgrounds or park your own trailer. Primitive roads make the backcountry accessible by 4-wheel drive and hikers can stagger to 14 campsites spread throughout the Chisos. There are many roadside exhibits with signage, pullouts and historical sites with burnable materials. Staff housing is concentrated at Panther Junction with maintenance facilities and offices for the park. Fencing and grasses supporting cattle along the park boundary, and wooden utility poles, could all be damaged by fire. Prehistoric artifacts have probably been burned many times and are more at risk from suppression activities than fire itself. Rugged terrain in the Chisos, ample fuels, few roads, and wilderness create challenges in the event of fire.

Safety issues

There have been 31 prescribed fires in the park since 1980. Two have escaped. The Casa Grande fire in 1999 led to fire shelter deployment, and atypical wind conditions during a small burn at the Big Bend gambusia ponds led to the loss of some cottonwood habitat. Lessons learned on these fires have been incorporated into new prescriptions and training in the park. Mistakes signal caution, but can also offer opportunities for learning and may provide some unexpected benefits such as establishment of cottonwood seedlings in ash beds near the gambusia wetlands. Buildup of fuels guarantees that sooner or later a natural ignition, human carelessness, or prescribed fire may escape, and the costs could be very high. Since 1980 there have ben 239 lightning ignitions burning 19,021 acres. Clearly the park does burn but burning successfully in areas with high fuel loads, proposed under alternatives B and C, will require skill and experience. Given the safety issues, the fuel loads and value to the public, it is suggested that training and assistance be provided by a ‘Hot Shot’ fire crew for initial prescribed burns in the Chisos. The ‘Hot Shots’ training of the entire fire program staff would be a cost-effective way to meet future difficulties of burning in areas with high fuel loads, wilderness designations, and obtaining local expertise in a remote park.

There is a single road into and out of the Chisos Basin which could make evacuations difficult in the event of a large fire in the area. An evacuation plan has been prepared (described in Chapter II) and prescribed burns along Green Gulch will lower fuels and reduce the possibility of fire from vehiclar traffic entering the Basin. Safe evacuation would be a challenge from the high Chisos where a wilderness designation means minimum impact suppression techniques (MIST) are required such as no motorized vehicles, use of hand tools only, and no airborne retardant drops. Superintendents can override these provisions and allow higher impact suppression methods when they perceive threats to life or property.

There are some provisions in place to safeguard visitors to the high country; hiker permit tags show fire conditions during high to extreme fire danger; rangers may be posted at trail entrances to talk with every visitor entering the high country and ensure they are aware of the danger; no smoking or open campfire signs may be posted during periods of danger; and, the Superintendent may close the area to protect people from possible fire dangers. Escaped camping fires were determined as the cause of the Blue Creek fire and Laguna Meadow fires. The measures taken to reduce fire risks are usually in association with fire precautions taken throughout the entire Lincoln Zone of the southwest area. Figure III-1 shows the peak of overnight campers in the Chisos occurs in March and early April coinciding with school and public holidays. Fourteen campgrounds are used in the Chisos with Juniper Flat (471), Colima (398), and Boulder Meadow (384) most popular. There were 3,639 permits issues in 2003 and campers stayed one or more nights.

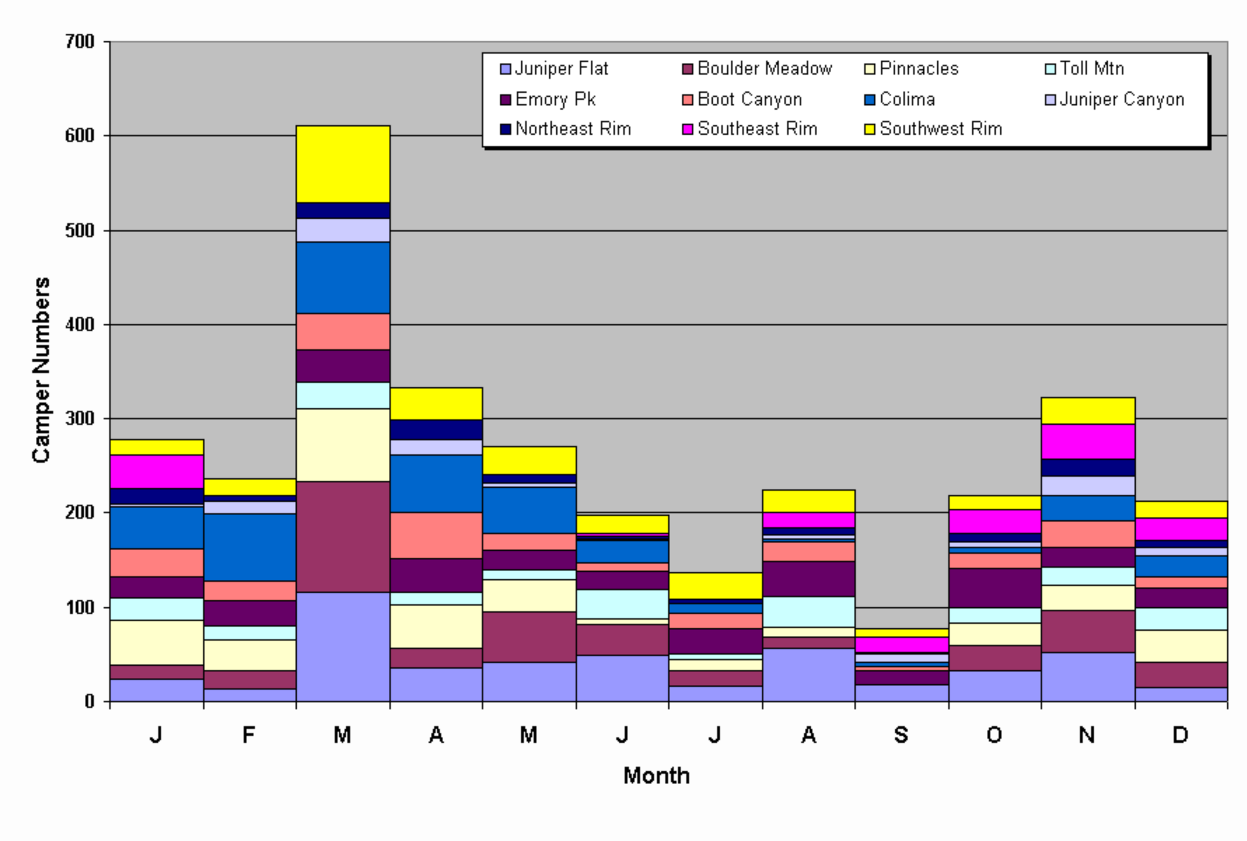


Figure III-1 Number of Campers, staying at least one night in the Chisos in 2003

Human caused fires are most prevalent during peak visitation times including spring break and Easter from March through May (71%-75% of fires), and during September vacation period (40% of fires). The percent of lightning caused fires ranges from 47% in April to a high of 83% in July falling to 56% in October. Most ignitions during November and December are caused by humans. Most fires are small. Of the recorded 543 fires in the park's history, 67 % are less than 1.0 acre in size and 94% are less than 100 acres. Large fires (>1000 acres) are few (9 recorded) and have been caused by lightning occurring in shrub desert with significant grassy understory. The greatest risk of fire coincides with peak visitation during the college vacation in March and Easter vacation in April when lightning strikes dry vegetation prior to the summer monsoon.

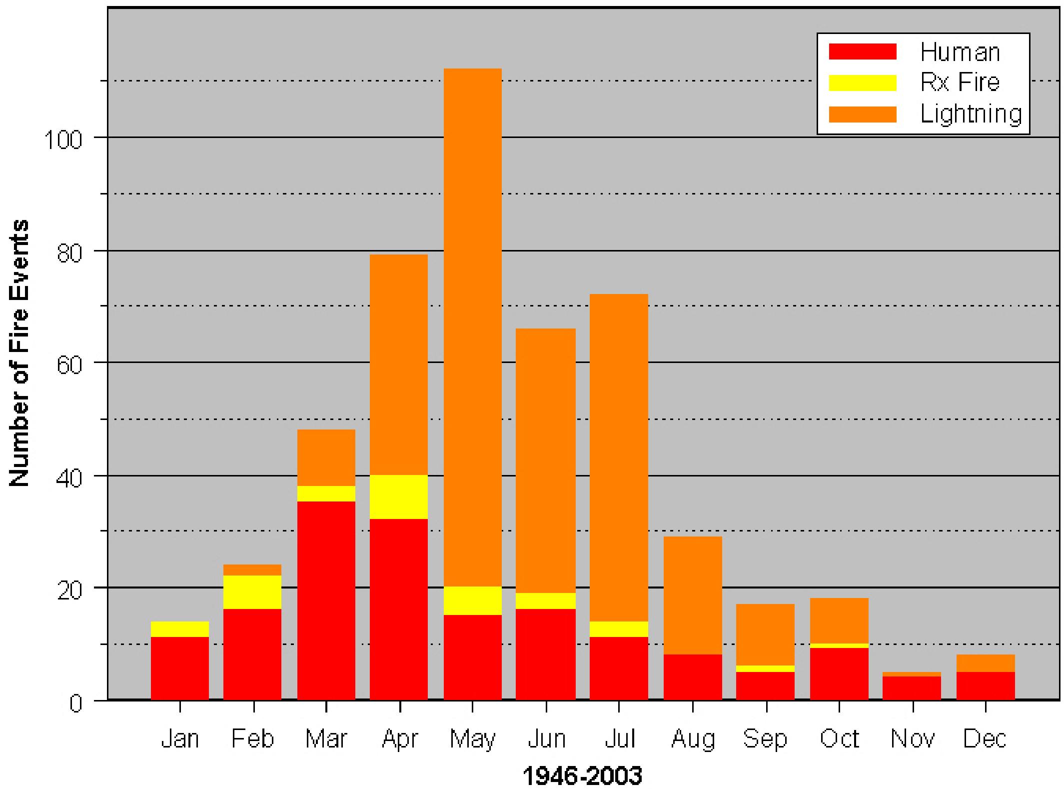


Figure III-2 Cause and Number of Documented Fires at Big Bend National Park.

Cooperative agreements with neighbors

The park seeks to collaborate with neighbors to develop a coordinated response to managing fire in the interest of safety, cost-effective use of firefighting resources, and better management of natural resources. Formal agreements outlining control of fire currently exist between the park, federal, state, other agencies, private landowners and Mexico (draft 1999). Under these agreements, the park agrees to suppress fires within approximately one mile inside the park border. The park also suppresses incoming fires because of its mandates to protect valued resources and because it has the equipment. Issues of safety, cost, and responsibility increase with expanded wildland fire use and prescribed burning under Alternatives B and C. Currently, fires must be controlled along arbitrary property lines which are drawn without regard to topography and vegetation conditions. The park proposes in the future to suppress fires at barriers such as roads, the river, and cliffs to improve safety for firefighters, cost-effectiveness of firefighting resources, and provide benefits for natural resources. Contacting neighbors to develop these new agreements will be an ongoing process. Special provisions will be made to include Mexican preserve managers in these negotiations as they too must deal with fires resulting from carelessness along the river corridor.

Challenges in identifying absentee landowners in gateway communities, and obtaining approval and funding for Mexican managers to travel to the park were noted at an IDT meeting at the park January 5, 2004. The impetus for contacting private landowners is that many neighbors are absentee landowners, most have settled from elsewhere and must learn behaviors that foster protection of resources, and all have an impact on the vegetation particularly around the northern and western peripheries of the park.

The difficulty of locating the many neighbors led staff to pursue development of boundary agreements with the largest neighbors and maintain the one-mile suppression buffer where there are many divergent viewpoints on proposed fire-suppression strategies, or where landowners cannot be easily contacted. Efforts to contact additional neighbors will continue when resources and time allow.

Fire Program Resources to Protect Life and Property

These issues are discussed under impact topic (8). The fire program has the capacity to handle current prescribed fires and small fires of short duration. To protect life and property under extreme fire conditions, the incident commander would request additional resources from the region and/or national office. Larger fires burning for longer periods on a routine basis, are possibly outside the capacity of the park current capacity to monitor and protect effectively. Additional support would be required from other agencies or the park would fill needed permanent and seasonal positions. The need for and type of positions are outlined under impact topic (8).

Impact Topic (2): Preservation of Visitor Experience

Approximately 300,000 people travel long distances annually to visit Big Bend. These visitations are testament to the unique experiences the park offers. Visitors can view the sheer canyon walls and park geology on a raft trip along the Rio Grande, abandon civilization in seemingly endless expanses of agave and yucca-strewn Chihuahuan Desert scrub, and be cooled by the oak-pine forests and grasslands of the Chisos - without even leaving the 110 miles of paved roads. Numerous hiking trails provide more energetic visitors with opportunities to experience these habitats more intimately and seek a glimpse of wildlife, view clear night skies, examine old mercury mines, and ponder life of former ranchers and merchants at historical homesteads. Exploring by raft or boat reveals the towering cliffs of the Boquillas, Mariscal, and Santa Elena Canyons and allows fishing in the Rio Grande. Naturalists appreciate this park. The mountains and riparian system that provides a vital corridor for migrating birds, mammals and the dispersal of plants between two countries and three interconnected mountain systems. The relative isolation of the park and its connection to other large protected landscapes has allowed the perpetuation of many rare and endemic species. The park botany research site currently lists 89 projects (12 Sept, 2004).

Visitors may camp within the park at the Rio Grande Village and Chisos Basin campgrounds, various primitive sites off roads and 14 designated primitive campsites in the high country of the Chisos. Motel accommodation and meals are available at the Chisos Basin but demand frequently outstrips supply. Other accommodations and supplies are more readily available in Study Butte and Terlingua 15 miles away, and at the luxurious resort of Lajitas, 40 miles from Panther Junction. The average stay in the park is three days, two days longer than most national parks. Alternate destinations for visitors in the event of fire-related closures with comparable amenities are few (Big Bend Ranch State Park and Black Gap Wildlife Management Area). The long distances involved in making alternate plans makes it imperative that park staff disseminate timely, accurate information forewarning visitors of potential inconveniences.

Communications about fire related activities will increase under the action alternatives. The park utilizes web site, radio, local press, signage, notices at visitors centers, adjoining agencies and local communities of any planned and unplanned road closures or other fire activities. Such notices will attempt to reduce inconveniences, promote safety, and provide information to aid understanding about fire wherever possible. Fuel buildups in areas of the park mean more fires are likely in the future. Staff perceive interpretation of fire events as playing a key role in the publics' acceptance of natural fire in the landscape. The larger interpretive center planned for Panther Junction will provide space for comprehensive treatment of fire issues at the park.

Impact Topic (3): Local Economy

The park lies within the counties of Brewster and Presidio. Median incomes for Brewster were 70% of the national average with Presidio residents making just 38% of the national average. Approximately 28% of Brewster residents live below the poverty line and 45% of Presidio residents (GMP, 2003). Any outside income clearly makes a positive difference for these residents. In 2000, 44,627 visitors stayed in concession lodging and 10,473 in the concession campgrounds of Rio Grande Village, Rio Grande Village Trailer Park, Cottonwood Campground, Chisos Basin, and the many backcountry sites (GMP, 2003). Lodging is also available in the nearby towns of Terlingua, Study Butte, Lajitas, Presido, Marathon and Alpine. The park represents a critical source of income for workers in these areas and dollars earned have multiplier effects in local economies.

Gateway towns surrounding the park are slowly growing. Subdivision of the Terlingua Ranch has led to more settlements on 20-40 acres along the dry western boundary of the park and in the townships of Study Butte and Terlingua. Some residents seek solitude, others community, but all are appreciative of the vistas of the park. The local economy is closely tied to visitation of Big Bend, with merchants supplying food, fuel, beds, souvenirs, and artisan wares from across the southwest. Some trained residents are recruited for firefighting when needed, others provide research and data collection when funding is available, and some support the park as volunteers. Vegetation is sparse around Terlingua presenting few fire hazards, but the growing number of landowners and seasonal visitors will require coordinated efforts to ensure inclusion in planning efforts and timely notification of fire program activities.

Los Diablos are US-trained Mexican firefighters employed on an “as-needed” basis to protect resources in both Mexico and the US. The park’s first recruitment and training of Los Diablos occurred in 1990, with the second in 1997. There are currently 32 trained Diablos. Firefighting provides important income for this group who frequently spend their paychecks on American goods.

Prior to closure of the United States-Mexico border at small crossings in and near the park along the Rio Grande, the web of economic benefits from the park extended across the border into the states of Chihuahua and Coahuila. For many visitors a trip to Big Bend included a visit to Boquillas, the Mexico township across from Rio Grande Village to eat at one of several restaurants and purchase arts and crafts. Mexican farmers also grew produce destined for restaurants in the U.S. at Study Butte, Terlingua, and Lajitas. Many of these small-scale entrepreneurs are now deprived of a livelihood as the nearest legal border crossing is 10-11 hours round trip from Boquillas via Del Rio, to Rio Grande Village. While the Immigration and Naturalization Service (INS) has created dispensations for Los Diablos, the Mexican fire crew, to cross at Boquillas, and is considering allowing other Mexicans dispensation to cross into the United States, border closure has created great economic hardship in an area with few alternate livelihood opportunities. Without access to legitimate income-generating activities, local people are increasingly forced to live on a subsistence basis, seek other ways to generate income, or migrate elsewhere. Since the border closure, there have been increasing incidences of theft from campgrounds, growth of illegal drugs along the river, and drug trafficking. There is also an incentive for arson to create jobs through firefighting.

Impact Topic (4): Vegetation

Big Bend lies in the middle of the Chihuahuan Desert flanked by rainshadow inducing mountains on the east and west. Low latitudes, and a 40-mile wide sunken graben in this basin and range landscape accentuate aridity and heat. The high elevation canyons and bajadas of the mountains, ephemerally filled arroyos and depressions, expanses of lowland deserts, and permanent waters of the Rio Grande support 1200 plant species within the park. This diversity is further shaped by limestone and igneous soils, extremes in rainfall from 4 inches in the low desert to above 16 inches in the Chisos, and temperatures from 100 degrees F to freezing. Out of the estimated 1000 endemic species throughout the Chihuahuan Desert more than 10% (120-130) are within Big Bend NP (Brown 1994). Unusual combinations of taxa particularly in the Chisos influenced the UNESCO Biosphere designation in 1976.

The gently sloping desert floor, features this desert's signature plant, lechuguilla as well as creosote, many cactus, and perennial grasses. Plant survival on these limestone soils depends on capture and storage of predominately (65-80%) summer rainfall in succulent stems, small, resinous or velvety leaves, and deep or widely spreading root systems. Depressions support alkali sacaton and tobosagrass. Terlingua and Tornillo creeks drain western and eastern portions of the park respectively into the Rio Grande River.

The Rio Grande once carried erosive sediments from as far as Colorado. With contributions from the Rio Conchos in Mexico, the river has carved through the limestone strata to create the breathtaking Boquillas, Mariscal and Santa Elena Canyons. The same scouring action of spring floods once scattered cottonwood forests and mesquite bosques sporadically along the river. Now tamed by dams, diversions, and groundwater pumping, the slow and diminished river flows are ideal for supporting the dense stands of exotic saltcedar along the shoreline, and giantreed in the river shallows.

More than ninety percent of the park is desert. The 7800ft Chisos Mountains facilitate the growth of woodlands and forests capturing sporadic summer thunderstorms from the Mexican Gulf, and the steadier winter rainfalls driven by Pacific frontal storms. Volcanic in origin and deeply eroded, the cooler moister northern slopes and deep gullies support conifer forests of Ponderosa pine, Mexican pinyon, Douglas fir, and bigtooth maple. Deeper soils at lower elevations support drought-tolerant oak and redberry juniper and shrubs. Grasses and succulents are found on exposed southern exposures and ridge tops. Rainfed pools and seeps from percolating water meeting bedrock nurture long-spur colombine and rare leopard frogs. These mountains, although just two percent of the park, pose most challenges to the fire program because they host great diversity of species and habitats amid rugged terrain. Grazing removed grasses that carried fire; suppression allowed leaf litter, ladder fuels and dead and downed to build. Now high desert grasses have recovered, can carry fire, and will do so into heavily fueled areas. Evidence of fire-scars in juniper suggest that this landscape has been shaped by fire over long periods, and that it is an important tool for maintaining ecosystem processes (Moir 1982).

Four elements affecting the fire program are discussed here: (a) interaction between fire and the six vegetation types at the park; (b) unique habitats requiring special consideration to ensure their survival and/or restoration; (c) treatment of designated wilderness, and (d) fire-adapted non-native plants that may be aided by increased fire. Vegetation categories have been assessed for condition (estimated departure from historical fire regime under the Fire Monitoring (USDI 2003), with III representing the greatest departure from historical conditions;) fuel model, which indicates the type and rate of spread of fire expected (introduced in Chapter II), current and desired structure, and common species.

The following vegetation categories are a further development on the 1994 FMP. Work of seven researchers was considered at that time and Plumb's (1987) research merged with Wauer's (1971) to yield four formations with many subcategories. The IDT reexamined Plumb's (1993) research and created six categories in light of current fire management considerations. Bray's historical reference (1901), and Brown's work on southwestern biomes (1994, 2000) were also consulted. Figure III-3 shows vegetation categories for the FMP at Big Bend, with Figure III-4 providing clearer detail of vegetation types in the Chisos.

(a) Vegetation Categories

<u>Floodplain/Upland Riparian</u>

Two cover-mapping categories, Mixed Riparian and Desert Willow from Plumb (1993) formed this vegetation category. The Rio Grande with a high watertable and dependable water year round supports considerable stands of vegetation, and although just 3% of the park, forms a vital lifeline for animals and humans. Historical photos taken in 1901 show a mostly denuded riparian corridor (Schmidley 2002). The erosive force of the spring floods kept the river clear of reedbeds and promoted scattered gallery forests of cottonwood and willow with sparsely vegetated floodplains of mesquite, acacia, screwbean, desert willow, and shrubby groundsel tree. Upstream dams in New Mexico now capture spring floodwaters. The Rio Conchos River 100 miles upstream provides valuable additional waters. Fire would have been uncommon prior to humans with lightning ignitions extinguished by high humidities and fuel moistures during summer. Understory was probably sparse. Now, fire can be supported with increased ground and ladder fuels from exotic species, which recover faster after fire than the natives. Fire is more frequent year-round from abundant human visitation and carelessness with campfires.

Upland Springs: Springs, seeps and tinjadas provide precious waters for wildlife and are found throughout the mountains and low elevation desert. They were claimed by ranchers and exotics gradually established. Now saltcedar is being systematically removed from springs and seeps allowing natives to reestablish.

Common species:
Floodplain -Big Bend cottonwood, honey mesquite, screwbean, willow, desert willow, acacia, common reed; exotics include saltcedar, giantreed, Bermuda grass and buffelgrass.
Upland springs – overstory varies with site; drooping and alligator junipers in moister sites with Emory and Chisos Oaks in less moist areas; alkali sacaton, deer muhly, blue and black grama grass understory.

This vegetation type has the following characteristics:

- Present structure: The floodplain is sparsely vegetated with dense stands on non-native saltcedar along the shore and giantreed thickets in shallow water. The historical intermittent gallery forests of native cottonwoods and honey mesquite bosques believed to exist prior to Europeans are found in small patches (Schmidley 2002). Native understory includes shrubby groundsel tree and desert willow. Introduced Bermuda grass and buffelgrass are dense where sun and moisture are present. Upland Springs dominant vegetation varies by spring; more mesic species including alligator and drooping juniper, and Graves and Emory oaks. Most saltcedar has been removed.
- Condition class: Floodplain –III; Upland springs to I- II (designation depends on whether they have they recovered from grazing impacts); Lower reaches of drainages –II; Headwaters of drainages –I
- Condition on recent burns: Wetlands: Rio Grande Village burn (2003) of moderate severity has shown high recruitment of cottonwood seedlings in ash beds. Other areas required additional plantings. Response to fire in the giantreed suggests regular burning at 5-yr intervals to reduce risk. Floodplains: Jewell fire (2002, 88 acres) between Mariscal and Santa Elena- arson set fire burned ~ 300 year mesquite bosque which is resprouting. Bermuda grass has responded vigorously after fire. San Vicente fire (2000, 27 acre) removed native overstory and saltcedar; both types of vegetation are resprouting. Upland springs: The history of exotics at springs suggests that fire may remove native overstory giving competitive advantage to more fire tolerant exotics. Other controls necessary following fire at springs.
- Fuel model: Floodplain –8 (Slow-burning ground fires with low flame lengths. The fire-supporting layer is composed of compact leaf litter, needles, leaves and twigs).
  Upland Springs – 3 (Fire is carried through tall grasses where one-third or more are considered cured or dead. Highest intensity of the grass fires, especially under wind.)
- Fire Cause and Frequency: Natural fire uncommon with high relative humidities and fuel moistures, wet soils. Human caused fires are common along the river.
- Insect/disease: None seen at present.
- Problem invasives: Large sections of the riparian corridor have saltcedar, with giantreed prevalent where the waters slow; buffelgrass established in upland arroyos.

Management Directions:
The major goals are to have scouring spring floods restored (beyond control of park), contain the spread of exotics and remove them wherever possible, gradually restoring native vegetation.

Floodplain: Staff are planning to contain exotics; initiate pilot restoration of natives; use fire when it occurs as part of an integrated restoration program for native species which may include sowing seed in ash beds and using herbicide to cut stumps of salt cedar; and, protect cottonwoods. Seedlings may need protection from rabbits and rodents as well as Mexican livestock, which ignore the international boundary. Saltcedar will be removed from arroyos as resources are available. Monitoring and photos will capture changes in exotic cover along the floodplain and arroyos associated with restoration projects and control of exotics.

Wetlands: Staff propose burning giantreed on a 5-year rotation to maintain endangered species habitat in selected localities.
Upland springs: Exotics will continue to be removed over time; mature native overstory species will be protected from fire wherever possible.

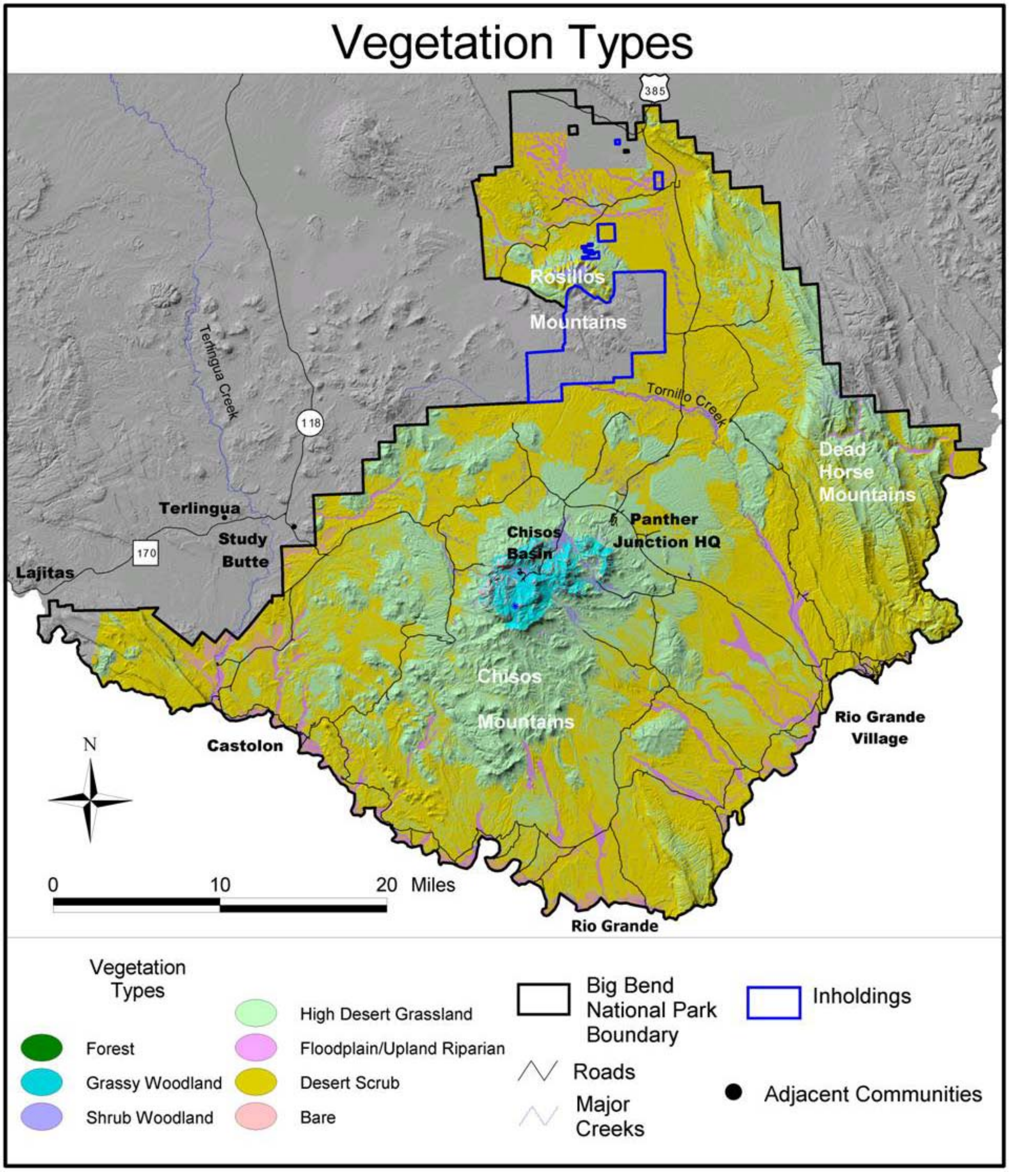


Figure III-3 Vegetation Categories under Big Bend FMP

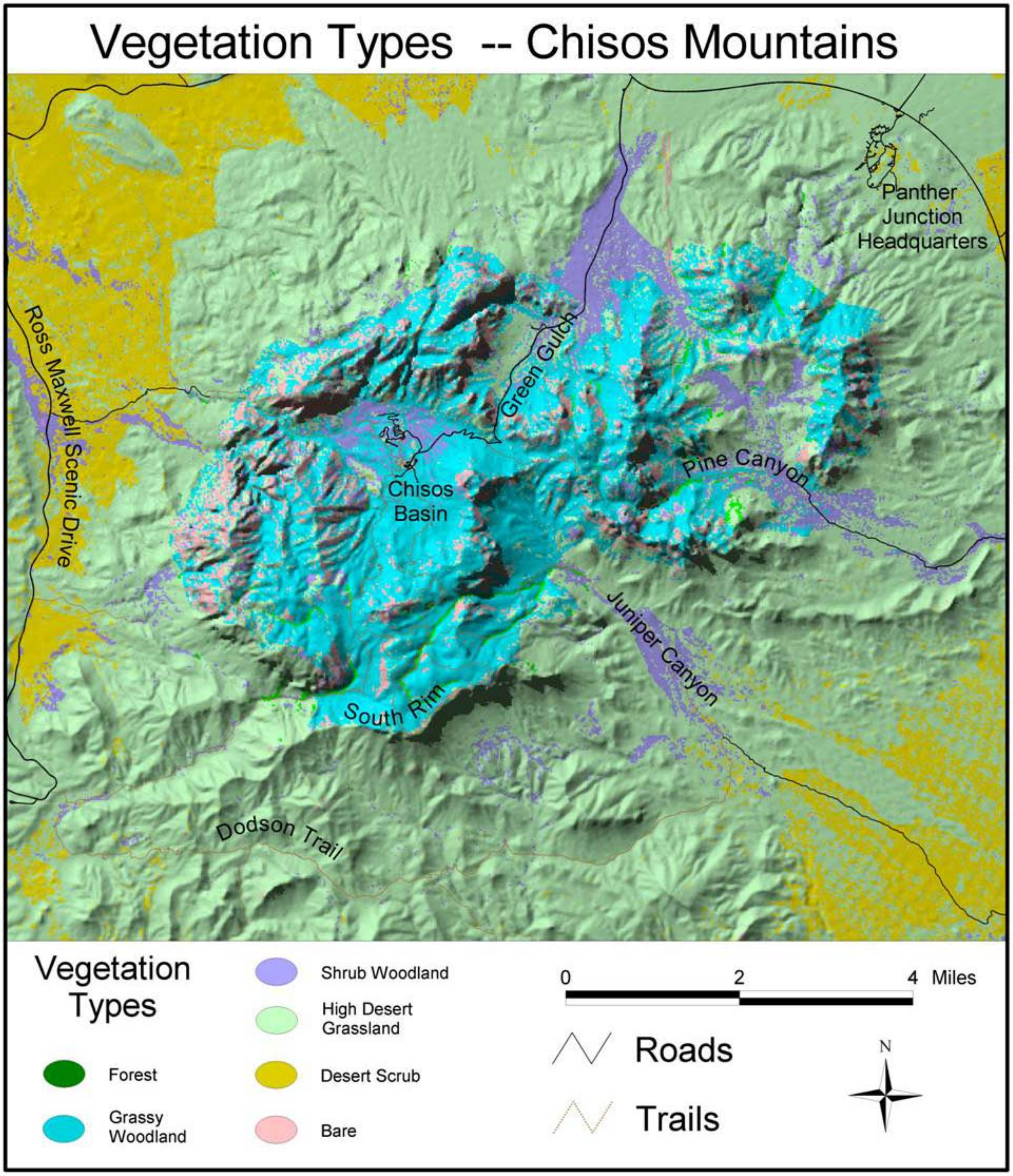


Figure III-4 Vegetation Types in Chisos Mountains

Scrub Desert:
This vegetation category was compiled from five cover-mapping categories from Plumb (1993); Creosote-Lechuguilla-Grass, Creosote-Lechuguilla-Prickly Pear, Creosote-Tarbush, Creosote-Yucca-Grass, and Lechuguilla-Candillea-Hetchia. Desert scrub is dominated by shrubs (creosote, mariola and ocotillo) and succulents (prickly pear, lechuguilla, and Texas hetchia or falseagave). Grasses are subdominent and provide insufficient fuels to carry fire. Scrub Desert occurs over half the park between the low-lying floodplains at 1,700 ft to mid-elevation desert grasslands at 3,000 ft. Average annual precipitation of 8-12 inches falls in winter and summer (mostly) with high rates of evaporation.

Common Species: Creosote, tarbush, lechuguilla, mariola, prickly pear, candelilla, hetchia, tobosagrass, sacaton, chino grama.

This vegetation category has the following characteristics:

- Present structure: Sparse desert shrubs, succulents and grasses. Grasses are unlikely to carry fire in this category but high winds may carry fire through shrubs. This is unlikely to be a fire maintained association because of the paucity of grasses. In the past there were more grasses including dense flats of tobosagrass on Tornillo Flat and fire may have been more common.
- Condition class: Where native shrub and succulents dominant –I (across most of the park); Arroyos invaded by exotics –II; Exotic grasses dominant –III. There is the risk of changing fire-regime adversely because these exotics respond more vigorously after fire than natives.
- Condition on recent burns: A prescribed burn in Comanche Draw, 6 miles south of Persimmon Gap in February 2003 (500 acres) showed a slight increase in grass cover from 1% in control plots to 2.5% in treated plots as a result of treatment by fire (McKernan 2003). Only one of past two years of above annual precipitation during the monsoon when grasses establish was included in results and grass recovery may be higher over the next year
- Fire Cause and Frequency: Lightning ignites fires are infrequent and usually do not carry far because of fine discontinuous grassy fuels (10-13% cover). Fire may carry through the shrub layer under high winds.
- Fuel model: 1 (Fire spread is governed by fine, porous and continuous herbaceous fuels that are almost cured. Typical of grasslands and grass-shrub assemblages and has high rates of spread.)
- Insect/disease: No problem areas at present.
- Problem invasives: Buffelgrass is colonizing arroyos that lead into the Rio Grande (Guertin 2004) converting shrub-dominated areas to highly flammable grasslands.

Management directions:
Major goals are to let natural fires burn within prescriptions and to use research burns to understand how fire may aid restoration of grasslands particularly tobosagrass and sacaton. Desert Scrub is the buffer zone to keeping buffelgrass out of high desert 'sotol' grasslands. Developing methods to aid grass establishment may help curb buffelgrass infestation. Fire at Comanche Draw shows that sites that increase moisture retention may increase recruitment of grasses in above average summer rainfall years (McKernan 2003). Options for buffelgrass areas are to suppress, or to burn and follow-up with additional controls. Experiments with and without herbicide following fire are proposed for the 1314 burn site joining highway 118, which also contains Lehmanns lovegrass. Monitoring using photos will be used to document changes in exotic cover, Warnock transects and circular plots, and, to document fire effects in natural burns and post-fire for selected prescribed burns.

High Desert Grasslands:
This is the most diverse vegetation category in the park, with the most species per unit area. High desert grasslands cover about 40 percent of the park ranging from 3,000 to 5,000 ft in elevation with scattered

plants occurring in the heights of the Chisos. Annual rainfall is 10-16 inches with most in summer. Lightning caused fires are common in this category and dependent on understory fuels. High Desert Grasslands can support large fires (>1000 acres) with sotol and yucca can act as receivers of lightning strikes and spreading fire as they roll downhill. Biological surveyor Vernon Bailey reported in 1901 that "Luxuriant grass covers almost the whole of the mountains …" (Schmidley 2002:350) suggesting more frequent fire at low and moderate intensities that maintained open canopies and grassy understory. The grasslands contained some shrubs, low-growing trees and cacti largely confined to drainages that supported little grass and to areas of rocky and shallow soils (Humphrey 1958). After 60 years without livestock, grasses in this category appear to have recovered from grazing.

Common Species: Lechuguilla, prickly-pear, bear-grass, sotol, viguiera, yucca, skeletonleaf golden-eye, ceniza, acacia, *Dalea* spp., grama grasses (Chino, blue, black, hairy and sideoats), tanglehead, lovegrass, California cottontop, green spangletop and threeawns, tobosagrass and alkali sacaton. Shrubs are found on drainages in deeper soils, with grasses, sotols and succulents found more on ridges and shallow soils. Exceptions are tobosagrass and sacaton on deep clay soils in undrained basins.

This vegetation type has the following characteristics:

- Present structure: Grasses are widespread on well-drained igneous soils and now support landscape scale fire (>1000 acres). Without fire, shrubs will increase onto shallow soils on slopes and ridge tops outside what may be their normal range in canyon bottoms.
- Condition class: I -with some shrub encroachment.
- Condition on recent burns: The Gap fire (1992, 2412 acres) at mile marker 4 on highway 118– showed considerable decrease in lechuguilla, recovery of grasses, and increased diversity; Sotol Vista fire (1981, 680 acres) caused by lightning shows recovery of grasses and shrubs, with catclaw and mesquite resprouting slowly; Estufa fire (1994, 3774 acres) near Panther Junction needs to be compared with equivalent unburned area to document fire effects.
- Fire Cause and Frequency: Caused by lighting; fire frequency estimated to be 7-10 years (McPherson 1995)
- Fuel model: 2 (Fire spread is from fine cured herbacious fuels in addition to litter and downed stemwood. Open shrublands, scrub oak and some juniper-pine assemblages fit this model).
- Insect/disease: None present.
- Problem Invasives: There is only one problem invasive, Lehmann's lovegrass, in this vegetation type. May or may not be spread by fire but certainly may be a primary contributor to fine fuel loading in the future. Will require specific monitoring following fire events.

Management Directions:
Major goals are to maintain and stimulate plant diversity, allow natural burns within prescriptions, shrink shrub encroachment along the grass-woodland ecotone, and develop natural firebreaks wherever possible.

Grasses have recovered sufficiently from grazing to carry landscape scale fires. Decreased competition during grazing and drought (7 years following park establishment) allowed shrubs to establish in preference to grasses. Several incremental burns may be necessary to remove shrubs where grasses from shallower soils on slopes and ridge tops allowing reestablishment of grasses. Ideally incremental fires will cause shrubs to contract to deeper soils along drainage lines and at the grasslands woodlands ecotone. Monitoring will detect changes in species diversity, fire effects, and use photos to document shrub encroachment.

<u>Shrub Woodland</u>:
This vegetation category contains three cover-mapping categories from Plumb (1993). These are Mixed Scrub, Oak Scrub and Mixed Oak-Shrub Woodlands. This category includes many different shrub

dominated communities scattered in the foothills and mountains of the Chisos Mountains and Dead Horse Mountains. Elevation is from 4,500 ft at Green Gulch to 5,500 ft near the Chisos Basin. Annual precipitation averages 12 to 16 inches.

Common species: Low growth Gray and Emory oak, catclaw acacia, catclaw mimosa, aloysia, slimleaf viquiliana, Evergreen sumac, Shorthorn jefea, and low-growth redberry and alligator junipers.

This vegetation type has the following characteristics:

- Present structure: The occurrence of shrubby thickets may be associated with human disturbance or higher precipitation at increasing elevation. Catclaw and bee shrub thickets are densest where stock camps, stock pens and homesteads were located. Evidence of grazing suggests that fires were also suppressed allowing juniper, pinyon and oak to increase and canopies to close. These woody fuels and thickets are generally not near ridgetops or areas conducive to lightning and have suppressed understory fine fuels, limiting the spread of fire. Fires are most likely to occur when high winds drive a grass fire into these areas.
- Condition class: II
- Condition on recent burns: Blue Creek (1989, 334 acres) human caused, burned the scattered overstory of pinyon and juniper at high-intensity causing high mortality; scrub-oak and shrub regrowth is very thick and grasses have responded strongly.
- Fuel model: 6 (Fire carries through the shrub layer at moderate wind speeds (8mi/hr) but drops to the ground at lower speeds and at breaks in the canopy.)
- Fire Cause and Frequency: Lightning prior to monsoon. Probably frequent surface fires that kept canopies open, maintained grassy understory and limited stand density, 10-30 years? (based on Kaib et al. 1996)
- Insect/disease: Some areas of oaks stripped in 1999 and 2000 by variable oakleaf caterpillar. Mild winters accompanied by drought stress possibly caused death of the trees.
- Problem invasives: Buffelgrass has established at the Chisos Basin, demonstrating adaptation to greater cold than has been recorded. Global warming trends may lead to reestablishment at burn sites during mild winters.

Management directions.
Major goals are to keep natural ignitions within low and moderate intensities; protect federally listed species habitat; restore areas heavily impacted by grazing in Green Gulch and Oak Canyon; and, create a plan for meeting fire moving upslope from high desert grasslands. Fires would thin juniper and pinyon saplings and reduce shrub cover. Results from monitoring would shape future management decisions. Monitoring will capture fire effects, condition of habitat for federally listed species, and coverage of bee brush and prickly pear where livestock camps were concentrated.

<u>Grassy Woodlands</u>
Grassy Woodlands contain three cover-mapping categories from Plumb (1993). These are Pinyon-Juniper-Grass, Pinyon-Oak-Juniper, and Forest-Meadow. These categories are found approximately 5,500 ft to 7,200 ft with more than 16 inches annual rainfall.

Common species: Mexican pinyon, redberry juniper, weeping juniper, alligator junper, gray oak, Graves and Emory oaks. Understory species of *Salvia* spp., Harvard agave, silk-tassel garrya, bull muhly, pinyon rice-grass.

This vegetation type has the following characteristics:

- Present structure: This category shows canopy closure revealed in an examination of black and white aerial photography between 1962 and 1991 by park staff. How extenisive this phenomina is currently under investigation. Fire-scar data suggest more frequent fire in the past prior to the grazing and suppression era (Moir 1982). General observation of the landscape shows frequent fire-scarred alligator junipers and charred woody debris on the ground. More severe fires would have consumed trees rather than left abundant scarring suggesting fires were grass carried and relatively fast-moving.

- Condition class: II
- Condition on recent burns: Fires larger than 100 acres include the Laguna Meadows (1980, 202 acres) and Casa Grande (1999, 230 acres). All were human caused and facilitated by the recovery of fine fuels at mid to high elevations.
- Fire Cause and Frequency: The present abundance of fine fuels would support landscape scale fires but they have not occurred. Lightning strikes may have been extinguished by rainfall or contained by topography, or part of a more complex cycle involving climate, species and anthropogenic factors. Moir (1982) conservatively estimated a fire return interval of 70 years.
- Fuel model: 2 - primary carrier of fire is now grass. Fire spread is from fine cured herbacious fuels in addition to litter and downed stemwood. Open shrublands, scrub oak and some juniper-pine assemblages fit this model.
- Insect/disease: Caterpillar damage on oaks.
- Problem invasives: None at present. Native bee brush has colonized areas disturbed by grazing.

Management directions:
Major goals are to manage this vegetation assemblage for ecological processes by allowing fires to burn within prescriptions at low and moderate intensities; protect sensitive resources where mandates direct; and, conduct research burns to learn more about fire effects and fire dynamics. Staff species diversity retained and fuels reduced. Monitoring will document fire effects and species diversity, particularly from research burns.

<u>Forest</u>
The Forest category contains two cover-mapping categories from Plumb (1993). These are Pinyon-Talus and Oak-Ponderosa Pine-Cypress. Forest occurs above 6,000 ft with annual precipitation above 16 inches and forms a mosaic of conifers and grassy woodlands with various other species. The abundance of dissimilar taxa was one reason for the UNESCO Biosphere designation in 1976.

Common species: Mexican pinyon, Graves oak, redberry, weeping and alligator junipers.
Distinct populations: Arziona cypress and Douglas fir in Boot Canyon, red oak in Western Chisos; quaking aspen on NW side of Emory Peak; one lateleaf oak and small numbers of netleaf oaks in the high Chisos; Texas madrone on north slopes and canyons, Chisos hophornbeam on slopes north of Emory Peak and Crown Mountain and in Boot Canyon, and also near Pinnacles Trail and upper Cattail Canyon.
Less common species: Ponderosa pine in Boot Canyon, Pine Canyon and Crown Mountain; Bigtooth maple in canyons and north-facing slopes; orchid of all species scattered throughout the Chisos; and Guadalupe fescue on the moist slopes of Boot Canyon.

This vegetation type has the following characteristics:

- Present structure: Fuel loads are high with continuous duff of 6-8 inches in places, 5-10 tones/acre standing dead and downed
- Condition class: II or III
- Condition on recent burns: Fire is expected to burn in this assemblage but it hasn’t. Perhaps there has been insufficient grass cover to allow fire to spread, fuel moistures have been too high during lightning strikes, fires have been contained by topography, or the public has engaged in clandestine fire-fighting efforts.
- Fuel model: 10 (considerable litter and 3 tonnes/acre dead and downed; high-severity fire likely burning soil organic matter, soil seed reserves, and canopy; stand conversion possible from forest to oak shrubland)

- Fire Cause and Frequency: Lightning caused in the past. Fire frequency estimates are currently being evaluated by the National Park Service and Yale University
- Insect/disease: Standing dead has some insect and disease damage; some death from variable oakleaf caterpiller. Damage may also have resulted from drought stress.
- Problem invasives: No problems at present.

Management directions:
Management challenges abound in this category. A mosaic of relict, sensitive, and charismatic tree species and other rare species covers the steep foot-accessible Chisos. Any high-severity fire in these fuels would require a heavy-handed suppression to save existing rare, threatened or special plants. Where possible fire would be let burn to natural boundaries such as cliffs or talus slopes, trail or roadway using hand tools only within prescriptions at low and moderate intensities. The challenge is how this is to be done. Research fires to understand fire dynamics will reveal how to safely reduce fuels in forest vegetation. Monitoring efforts will be applied to natural, research and prescribed fire in this category to document species diversity and understand fire effects and dynamics in particular species, habitats, and terrain. Vancat (forthcoming) proposes that high-severity fire has not occurred in the North Rim of the Grand Canyon's mixed conifer forests because of heterogeneous topography. This offers a possible explanation for the lack of fire in the Chisos despite abundant lightning strikes and heavy fuels. Research burns will be associated initially with mesic environments which represent late successional stages in forests and most likely to indicate effects of fire in valued habitats.

(b) Unique Habitats

Six habitats are determined as unique within the park and highly valued by visitors. These are mountain meadows, Chisos grasslands, upland springs, limestone habitat, dunes, and Chisos woodlands and forest. Most of these habitats occur within wilderness, which guides management strategies.

Mountain meadows contain a mix of grasses, forbs, semi succulents, shrubs and small tree species. Meadow assemblages are assumed to be maintained by periodic low-intensity fire, a succession stage following disturbance in forested ecosystems (Patton 1992). Lynn Loomis (Marfa NRCS) suggests that soil composition and depth may also influence succession and species. He noted that the meadows are found in depressions with deep soils (60-80") high in organic matter and mollisol-like, with species not found in nearby landscapes (Personal communication, January 2004). Stopher (1998) however, found oak species encroaching on Laguna Meadow suggesting that over time the meadow may eventually revert to woodland. Nabi (1978) in a successional study of pinyon-juniper found fire a necessary agent in preventing tree encroachment into meadows. A prescribed burn planned for the South Rim will burn some of this meadow and results monitored long-term to better understand succession and management needs. New growth following burning may benefit the Yellow-nosed cotton rat, an edemic species.

Limestone habitat occurs across much of the eastern portion of the park. This soft sedimentary rock laid down when the park was covered by an inland sea during the Triassic Era, is readily permeable to water but has low water holding capacity. Plant communities are strongly shaped by the physical and chemical properties of this soil. Growth on these formations is limited by high ph due to dissolution of the calcium carbonates releasing hydroxide ions making other nutrient cations less available (Bohn et al, 1985). Low annual precipitation (4-12") and high evaporation means low organic matter and water-holding capacities in soil. Adaptations to arid conditions abound. Shrubs like creosote and acacia have spreading and deep roots with waxy or resinous leaves. Succulents store water in stems like lechuguilla and cactus. While creosote and lechuguilla will burn, fire is unlikely in these habitats. The fine understory grasses that carry fire are sparse (10-30 percent of cover) and discontinuous.

Upland springs were the mainstay of the short-lived ranching industry (Gomez, 1991). Saltcedar established in many of these sites as it was readily dispersed, established easily, and was widely promoted for erosion control and stabilization throughout the U.S. In recent years, staff have been applying herbicide to flushcut stumps to prevent reestablishment. In the event of fire, follow up treatment will prevent reestablishment of saltcedar, exotic bunching grasses, blackberries or other non-natives. Native species in these areas include the more moisture dependent Graves and Emory oaks and weeping and alligator junipers.

Dunes cover several acres near Boquillas Canyon on the eastern side of the park. They formed through the erosive action of wind and represent an uncommon landform in the park. Vegetation is sparse and not expected to burn except where buffelgrass has established. The dunes are possibly at greater risk from trampling, cavorting down the slopes, or vehicles drived off-road. The globally rare Bigpod bonamia grows among these dunes.

Grasslands refer to two types; high desert grasslands characterized by well-drained igneous soils and sotol, and low desert grasslands found in depressions found on poorly drained, fine textured clayey soils overlaying carbonate soils. Grasslands on igneous soils of the Chisos appear to have recovered after 60 years rest from grazing. These permeable, well-drained soils support blue, black, hairy and sideoats grama, tangelhead, green sprangletop, lovegrass and muhly on moister northern slopes. These grasslands also support a range of shrubs, semi-succulents, succulents and tree species. Higher elevation and precipitation has aided recovery. Now these grasses will carry fire. Of great interest to park staff are the tobosagrass and sacaton on fine-textured soils in depressions. Although Langford (1952) reported riding through high grasses to Hot Springs (probably through Tornillo Flat), they have not recovered with removal of livestock. Desiccation periods between summer rains combined with continued erosion downslope of plants is thought to limit reestablishment. Staff are planning small research burns to test recovery on flat areas. Brush and contouring will be applied after burning to prevent erosion from these sites. Fire return intervals are expected to be longer in more arid areas where biomass recovery is slower. The US FEIS site suggests 30-250 years.

The Chisos woodlands and forests contain many taxa and habitats within 40 square miles or 2 percent of the park. The eroded remains of magma plugs form cliffs and deep gullies where woodland/forest types overlap in the same habitat, different habitats occur at the same elevation but are separated by aspect, and where relict and rare species occur serendipitously in the midst of common species. Of the estimated 100 endemic species in the Chihuahuan Desert (Brown 1994) more than 10 percent occur in Big Bend National Park, many of these in the Chisos.

(c) Designated Wilderness offers unparalleled scenic and recreation and also constrains management options. The park has 533,900 acres of proposed wilderness and 25,700 of potential wilderness. These areas exclude developments, cultural sites, roads and their surrounding buffers. Congress requires these areas be managed as wilderness whether proposed, potential or legislatively approved. The result is a park relatively undeveloped with vast views, little noise and many opportunities for solitude. Park borders are expanded by other protected landscapes nearby. One mile to the southwest of the park is Big Bend Ranch State Park (300,000 acres). Abutting the northeastern park border is Black Gap Wildlife Management Area (83,000 ares), and to the south Canyon de Santa Elena Preserve (208,381 hectares) and Maderas del Carmen Preserve (277,209 hectares). Together these protected areas create more than a 1.67 million acres of wilderness – a unique bioregion crossing two countries and many habitats within the Chihuahuan Desert.

The area offers outstanding opportunities for primitive and unconfined types of recreation. A wilderness designation also means that fire suppression activities will be conducted without bulldozers, planes for retardant drops or chainsaws to remove trees or shrubs- less efficient control methods but less invasive on the landscape. Minimal impact techniques are intended to maintain areas that appear to have been primarily affected by the forces of nature and not by humans. The Incident Commander or the Superintendent can override suppression tactics in wilderness for safety reasons.

(d) Exotic plants Fire may aid invasion of exotic species but may also prove to be a control tool. Approximately 50 exotic plant species are found in the park (Sirotnak 1998). Seven were determined a threat by the IDT to native species in the park because of their ability to replace native species and alter plant community structure and ecosystem function. These seven species are saltcedar, buffelgrass, Bermuda grass, Johnson grass, Lehmanns lovegrass, Russian thistle and giantreed.

Nonnatives or exotics are those species, which did not originally occur in the ecosystem but are currently present because of disturbances. Seeds and/or vegetative parts traveling by wind, water, vehicles, attached to animals and human sox, get established at sites disturbed by fire, flood, drought, disease, changing light, moisture, changed nutrient conditions and physical disturbance. Their success depends on their ability to exploit resources more effectively than native species. Exotics are especially noticeable along roadsides, arroyos, the Rio Grande, and around human habitations. Saltcedar, giantreed, Bermudagrass, Johnson grass and buffelgrass tend to form dense monotypic stands that reduce plant diversity and are less valuable to wildlife than native species. Lehmanns lovegrass is also adapted to fire and spreading into nearby native desert grasses. Russian thistle morphology facilitates the spread of fire.

Saltcedar: Introduced to the US from Asia as an ornamental in 1823, three invasive species have now naturalized many floodplains, streambanks, river courses, marshes and irrigation canals with shallow water tables and minimal erosion in the southwest. Pure dense stands characterize the Rio Grande corridor along sections of the park boundary. It creates litter and ladder fuels and survives fire by prolific seed set, resprouting roots, and layering of buried stems (Carpenter 1999). Seed and flower production following fire is greatly increased (USFS FEIS data base). Saltcedar appears a colonizing species that tolerates burning about every 15-20 years. Herbicide application to freshly cut stumps kills saltcedar and replacement with other species is essential to prevent reestablishment. Widespread infestations may alter wildlife habitat and use, and affect local water uptake and drainage patterns (Lair and Wynn 2002). The 118 miles of riparian corridor is unlikely to be restored in the near future because of insufficient resources and upstream diversions and activities. Several pilot projects in 2006 however, will remove saltcedar along the river corridor and establish native plant species. Saltcedar has been progressively removed from most springs and seeps in the park.

Bermuda grass: A summer growing deep-rooted perennial from Africa introduced to Southwestern pastures to boost livestock production. Survives fire primarily from regrowth of underground rhizomes and from prolific seed production. Can be controlled by deep shade, long-term drought during the growing seasons, and extended freezing temperatures. Firmly established along the river and near human developments across the park. Additional fuels increase flammability and likelihood of fire in an area used often by the public. Control is best achieved with herbicide application.

Buffelgrass: Another species from Asia and Africa introduced to boost range production for livestock. Dense clumps crowd out native grasses and provide abundant dry fuel for carrying fire. Plants resprout vigerously following fire and are prolific seeders. Frequent fire favors this species and could cause the decline of species less tolerant of fire such as cactus and other natives (Tu 2002). A recent survey revealed that buffelgrass has moved from along the river corridor into drier arroyos (Guertin and Halvorson 2004). The park is focusing removal efforts around endangered species.

Lehmanns lovegrass: Imported from Africa for increasing pasture production, Lehmanns lovegrass colonizes disturbed and undisturbed sites successfully (Anable et al. 1992). Staff suspect this grass was part of the seedmix used to stabilize highway 385 roadsides during an upgrade about 35 years ago. Since then it has steadily invaded grasslands adjoining the road. Mowing of the roadsides before seedset helps reduce invasion into nearby grasslands.

Russian thistle: Russian thistle occurs along roadsides and other disturbed areas germinating with summer rains from seed. It becomes stiff and rounded at maturity breaking off in high winds to 'tumble' along - an ideal carrier of fire. Mowing of roadsides at strategic times limits populations and seed set. Intolerant of competition, Russian thistle can be reduced by establishing desirable plant species. Manual and mechanical treatment is effective.

Johnson grass: Originally from the Mediterranean, Johnson grass is a widespread perennial forming almost pure stands in richer soils such as depressions formed by road drainages. Frost topkills the plant but it spreads readily from rhizomes and seed when moisture is available and is difficult to eradicate sending rhizomes as deep as 120 cm (newman 1993). Staff believe the plant is relatively isolated at the park in roadside depressions but cycles of wet years (2003-2004) allows new sites to be established as seeds are carried in runoff. Fires would burn hotter and may damage less fire tolerant native species.

Giantreed: Giantreed has colonized the shallow slow moving river edges. The reed produces masses of rhizomes and stems, which can create ladder fuels into tree canopies. The vigor and denseness of growth excludes native reed and offers fewer opportunities for wildlife. This cane burns rapidly and hotly even when green, spreading to other nearby vegetation (Bell 1993). Park staff burned some giantreed in 2003 and intend to followup on a 5-year cycle in some areas to improve native species habitat.

Exotics increase after wet years and after repeated fires suggesting that methods other than fire be the major control of fire-adapted nonnatives (Brooks and Pyke, 2000). The park has a multi-pronged approach to address nonnative plants in the park including control of further infestations, removal and restoration with native plants, and systematic study to learn about life histories, rates of spread and control measures. A 1998 roadside study classified weeds according to their (1) ability to become a problem, (2) relative ease of control, and (3) current impacts on native plant communities in the park (Sirotnak, 1998). The park calls upon the services of The expert NPS Exotic Plant Management Team (EPMT) based at Carlsbad Caverns NP to help with removal primarily of saltcedar at selected sites. The volunteer "Buffel Bashers" also assist with management of exotics at the park. The size of the park, time to familiarize and train staff, has resulted in roughly two weeks of effective work by the EPMT team each year and exotic bunching grasses are spreading increasing flammability of native plants (Joe Sirotnak, personal communication, 2004). Exotics will be manually removed from around legally protected species wherever possible to reduce risk of fire injury. Appropriate control measures will be used to control exotics if needed after prescribed and natural fires.

Impact Topic (5): Threatened and endangered species

Great biological diversity within the region has arisen as plants and animals have adapted to extremes of temperature and rainfall, mountains and river plains, and differing properties of limestone and igneous soils. The park contains a number of sensative species. A number of these species have been recognized for their rarity and are granted protection under the Endangered Species Act. This sample however, hardly represents the wealth of wildlife throughout the park, which includes the southernmost extremes of some species such as Black-capped vireo in the United States and the northernmost extremes for some Mexican species such as Colima warbler. A general overview of wildlife species is presented followed by tables of those species considered for effects under the fire program. The same format is followed for plant species.

Wildlife

The Chisos provides a small refuge for state-Threatened black bear and the charismatic mountain lion, just two of 70-75 mammals that use the park. The viability of bear populations relies on travel routes to Mexican mountain habitats, which repopulated the Chisos following their extirpation prior to park establishment in the mid-20th century. Since recolonization of the park in the late 1980's, the bear population has fluctuated from a high of at least 30 individuals in 2000 to as few as 6-10 in 2001, following severe drought-induced food shortages. (Raymond Skiles, personnal communication, August 2004). Mule deer are commonly seen, particularly in high desert grasslands while Sierra del Carmen whitetailed deer are usually found at higher elevations. Bighorn sheep, once established in the river canyons and arid mountain regions, were extirpated by hunting and disease transmitted from domestic livestock.. Black Gap Wildlife Management Area on the park's northeast border has reintroduced them, which staff hope will lead to recolonization of the park. Smaller mammals such as skunks, rabbits and rodents complement the mountain lion's main diet of deer and javalina. Gray fox, Black-tailed jackrabbits and coyotes may be seen along riparian areas or in desert scrub, particularly at dawn or dusk when heat and aridity are less harsh. The endangered Mexican long-nosed bat, and the Western pipistrelle can be seen against an evening sky particularly around the mountains.

Sheltering mountain ranges and assured water provide routes for birds migrating between countries and hemispheres. The location and diversity of habitats gives rise to more species per unit area (6.3) than the Guadalupes (1.2), Davis Mountains (1.01) or Madreas del Carmen (0.63) (Wauver and Ligon 1977; Wauver and Riskind 1974). There are an estimated 450 species that have been observed in the park with approximately 100 species nesting each spring. Mesquite along the river provide habitat for Yellow-billed cuckoos. Black phoebe is common and the yellow-breasted chat can also be seen along the riparian corridor. A lucky visitor to the Rio Grande may see Common black hawks and Gray hawks nesting or beaver feeding along the bank. In the drier desert habitat, cactus wrens dart after insects and reptiles, curve-billed thrashers hunt insects, roadrunners are not uncommon and turkey vultures hover over the landscape watching for carrion . Loggerhead shrikes skewer bugs on thorns in high desert grasslands where mockingbirds and the brilliantly colored orange and black Scotts Oriole is also found. Higher elevations of oak, juniper and pinyon pine woodland, with grassy and shrubby understory are more mesic and support broad-tailed hummingbirds, bushtits, gnatcatchers, gray-breasted jay and screech owls. These oaks and conifers also provide for the acorn woodpecker, Northern flicker, Colima warbler and Rufous towhee. Elf owls are found along a broad elevational range and can be seen nesting in telephone poles in desert scrub, and in cottonwoods at springs and along the Rio Grande.

One of the goals of the proposed research program is to understand the role of fire in the restoration of lowland desert grasslands. Greater areas of tobosagrass may attract Northern Aplomado falcons now established 100 miles northwest of the park at Marfa, and create more reliable habitat for Peregrine falcons, and other raptors.

The Texas horned lizard is one of 56 reptile species in the park, and is on the State of Texas list of threatened species. Its home is sparse vegetation in desert scrub, making reliable population estimates difficult. It is unlikely to be affected by more burning as its habitat lacks fine understory fuels to carry fire. More commonly seen species in desert scrub or grasslands are the coachwhip and Trans-Pecos rat snake . Diamondback and black-tailed rattlesnakes are occasionally seen. Only after summer rains fill ephemeral ponds do Couch's spadefoots and green toads surface in abundance.

Probably most at risk are the aquatic species (including 29 remaining native fish species) due to Rio Grande diversion, alteration of flow cycles, contamination and exotic species invasion.. Six native fish species no longer exist in the Big Bend region, including the endangered Rio Grande silvery minnow; seven of the remaining fish species are species of concern. Only dead shells of mussels have been found in recent years; the Texas hornshell is a species of concern. These impacts are not easily addressed as the legal and political authority for river use and management decisions lie outside the park's jurisdiction.

Staff identified 11 protected species likely to be affected under the fire program in Table III-1. The management trajectory and safeguards under the preferred alternative suggested that only two federally listed species may be impacted by the FMP. These are the Mexican long-nosed bat and the black-capped vireo. The park has written a Biological Assessment (BA) that describes plans for limiting impacts to these species for U.S. Fish and Wildlife Service review. Measures to protect these species and their habitat include: prescribed burns to reduce fuels and protect habitat from high-severity fire; research burns to understand fire dynamics and desired fire intensities; multiple measures to avoid or minimize direct damage; and, mitigative measures should damage occur. Staff will review the fire program annually to incorporate monitoring information, fine-tune prescriptions and incorporate lessons learned into fire operations. A database of fire effects on habitats through will be created from monitoring of prescribed and natural burns when resources permit. Resource managers have focused research efforts on better understanding life histories of selected species such as the black bear, and targeting the effects of fire on the habitat of endangered species to support these populations. Research efforts are generally partnerships between staff with local knowledge and expertise and scientists from academic institutions.

Wildlife

Gambusia gaigei -Big Bend gambusia
USFWS –Endangered ; TPWD – Endangeredthreatened
Warm springs near Rio Grande Village supply freshwater to three ponds containing Big Bend gambusia. The fish are estimated to have survived since the Pleistocine, having adapted to specific and consistent warm-water conditions. Several cautions have been expressed in relation to prescribed burns in the area. These are the loss of shade, runoff-borne ash and sediment from burns upslope, changing ph as a result of ash, and fuels or other contaminants resulting from suppression activities.. Placement of logs and branches to provide shade, foraging and hiding habitat will be used if needed after future burns. A recent prescribed burn deposited significant ash in one of the ponds, yet post-burn mosquitofish monitoring revealed no apparent mortality. Paying attention to vehicle placement and rerouting any spills away from the ponds will mitigate risks from fuel or chemical spills.. A boardwalk made of recycled materials could pose a toxic threat if burned. Prevention of high-density and high-risk fuel buildup through appropriate prescribed burning is intended to reduce risks associated with intense fire around mosquitofish habitat.ent burning. An equally significant risk to gambusia is humans introducing exotic species, such as bait or aquarium fish into the ponds (Clark Hubbs, Cary Coventry and Raymond Skiles, personal communication April – June, 2003).

Leptonycteris nivalis -Mexican long-nosed bat
USFWS-endangered; TPWD – endangered
This migratory bat ranges from southern Mexico into Texas and New Mexico. There is one major roosting site in the park where young are reared. Annual visitation by bats varies seasonally, perhaps in response to varying availability of their food source, nectar of century-plant agaves. The main threats to the bat are destruction of roosting sites and foraging habitat. Wildland fire may at least temporarily reduce agave populations in burned areas. Proposed mitigation measures include maintaining 80% or more of agave habitat all times. Mature agaves can survive low intensity fire (Powell 1996; Johnson 2001). The well-ventilated roosting site could draw smoke and heat into the cave if fire came close to the entrance and will be protected by managing fuels downslope of the protective shield of vegetation covering the opening.

Vireo atricapilla- Black-capped vireo
USFWS-endangered; TWPD-endangered
Twenty three of these insectivorous songbirds were observed in the park in 2004 (Maresh 2004). Vireos are found from Oklahoma to Coahuila in Mexico. For nesting habitat, they require 6'shrubs with foliage extending to ground level. Shrub species appears less important than the presence of a mix of broad-leaved shrubs, foliage to ground level and a mixture of open grassland and woody cover, usually containing juipers. Shrubs occupying 30-60% or more of the total cover seem preferred (USFWS 1995). The courtship and nesting period last from mid March through mid-September. Vireos are vulnerable to

changes in habitat, particularly through plant succession, and nest parasitism from Brown-headed Cowbirds.

Sensitive Species

The most apparent are black bear, mountain lion, Desert Bighorn sheep. Desert Bighorns were reintroduced introduced into Black Gap Wildlife Management Area to the northeast of the park in 2000, and some have migrated into the park. Desert Bighorn are also being re-established south of the park. It is hoped these initiatives will result in their restoration in historic park habitat. Desert bighorn favor sparsely vegetated areas without visual obstruction. Fire may play a role in maintaining or restoring this habitat. The Colima warbler is at its most northerly range in Big Bend and avid birders travel the country to find it. Mountain lion are mobile and follow prey and are not legally protected outside the park. The small black bear population is sensitive to fluctuating food supplies, and even temporary and local habitat changes during drought periods may have negative results   Of particular concern is loss of reproducing females, of which there were only two known in 2004. A significant risk is management removal of bears, particularly females, due to bear/human conflict that could result from improper food or garbage management by park visitors or residents Small burns that maintain mosaics of bear habitat are best for maintenance of bear food sources.

Coccyzus americanus- Yellow-billed Cuckoo
USFWS- Candidate
The Yellow-billed cuckoo has been seen feeding on caterpillars in cottonwood and mesquite groves near Rio Grande Village (Mark Flippo, park biologist at Big Bend, personal communication January, 2004). It is unknown whether stands of salt cedar offer the same food resources for the birds. Any fire in the river corridor that burns salt cedar or exotic vegetation will be followed up with herbicide treatment to prevent re-growth of exotic plant species. The fire program as a component of native riparian tree restoration is ikely to benefit the cuckoo.

Eumops perotis californicus -Greater Western Mastiff Bat
USFWS- SOC
The Greater Western mastiff bat roosts in crevices in canyon walls and flies the river corridor, seeking insects attracted to riparian vegetation. Unless fire occurs directly under a roosting crevice the bat, being mobile, is unlikely to be negatively impacted by the fire program.

Falco peregrinus anatum -American Peregrine Falcon
USFWS- Delisted
The Peregrine falcon nests on cliff ledges in the park and under delisting criteria will be monitored every three years for 15 years. In the event of fire, falcon eyries will be designated sensitive areas and a buffer of ½ mile established vertically and horizontally from each site. Fire management operations will avoid these sites during nesting season from February 15 to July 15.

Phrynosoma cornatum -Texas Horned Lizard
USFWS- SOC, TPWD - Threatened
This lizard occupies the open ground of desert scrub, making estimating its numbers a challenge. Natural ignitions in desert scrub are unlikely to impact the lizard as limited and discontinuous fuels only support patchy fire under high winds.

Popenaias popei -Texas Hornshell
USFWS- Candidate
Texas Hornshell is a mussel that is still believed to inhabits the Rio Grande in small numbers. Recent surveys have revealed only dead shells, but no living specimens. Altered flow, increasing salinity and

contaminants are thought to be reducing numbers. The proposed alternative is not expected to have any additional adverse impact on this species.

Ursus anericanus mexicanus -Black bear
TWPD – threatened; Mexico- endangered
Following extirpation from the Big Bend region, it took 50 years for black bears to recolonize the Chisos Mountains. A small number of bears, including at least one female, migrated from the Sierra del Carmen of adjacent Mexico in the mid-1980's. Frequency of bear sightings increased from 1988 through 2000, when at least 30 individuals were known to inhabit the park, including five breeding females (Onorato, 2003). Drought-induced mast (soft and hard nuts and berries) failure is thought to have resulted in a severe population reduction. In 2004, only two breeding females were known among the 8 – 15 bears thought to to inhabit the park in 2004 (Raymond Skiles, personal communication, 2004). They need forest and woodland habitat to supply the high-mass, high-calorie foods for fall hibernation. Research is needed to develop an ongoing bear population and bear food monitoring program. Such a program would inform fire strategy development. In the absence of such information, the best fire policy appears to burn small areas while maintaining mosaics of intact vegetation, and monitor pre and post-fire vegetation.

Apodemia chisosensis -Chisos Metalmark
TNC G1 Critically imperiled because of extreme rarity
Chisos metalmark is an endemic butterfly and possibly derived from the Nais Metalmark found to the west of the park. The host is *Prunus harvardii*, a shrub to six feet and found mostly in the Chisos scattered along drainages, high desert grassy woodlands and ridge tops. The butterfly is reported most commonly in Green Gulch, which is readily accessible from a near-by road but other populations may be present. Fire could destroy habitat along drainages but rejuvenate grassland habitat.

Table III-1: Special Status Wildlife Species Associated with Big Bend National Park

Common Name	Scientific Name	Status	Habitat Type
Species whose entire population might be affected by a high-intensity fire			
Black bear	*Ursus americanus mexicanus*	State T	Forest and woodland habitat with many shrubs to supply high mass, high calorie food. Seasonal use of diverse desert arroyo food sources. Large high-intensity fires could cause bears nutritional stress, and result in them migrating out of the park. Small, prescribed fires outside breeding and peak feeding times would cause least disruption.
Species whose local populations may be affected by a high-intensity fire			
Greater western mastiff bat	*Eumops perotis californicus*	Federal SOC	Common in river canyons, which are not likely to burn. Feed on insects populations along the river but can forage beyond burned areas.
Mexican gray wolf	*Canis lupus baileyi*	Federal E, Ex, State E, Ex	Experimental populations are being established in southeast Arizona from 1998. Wolves travel 30 miles to hunt, and may travel 500 miles to find new territory, possibly finding their way into the park. Prescribed or wildland fires are unlikely to pose problems unless females have young.
Mexican long-nosed bat	*Leptonycteris nivalis*	Federal E, State E	The bat feeds on agave blossom nectar from 3500-7800' primarily in oak-juniper woodlands. Fires are ideally small to limit damage to agaves and roosting sites or patchy to preserve areas of agaves.
Black-capped vireo	*Vireo atricapilla*	Federal E, State E	Requires shrub woodland with large 6' shrubs to the ground. Fire would adversely impact currently inhabited areas. Prescribed fire useful for research burns to improve habitat.
Peregrine falcon	*Falco peregrinus*	Federal DC, State E	Nests on cliff ledges from mid February to mid August. Suppression activities including overhead flights would be highly disruptive.
Northern Aplomado falcon	*Falco femoralis septentrionalis*	Federal E State E	Not currently in the park but established near Marfa, 100 miles NW. Fire in grassland would increase prey post-fire and lead to more prey long-term. Nests on trees and other shelters in grasslands
Yellow-billed cuckoo	*Coccyzus americanus*	Federal C	Nest primarily in mature cottonwood from March through September. Forage in mesquite thickets for fuzzy caterpillars.

			Fires need to be small and low intensity, to protect roosting and foraging sites.
Species likely to be adapted to fire or unaffected by high-intensity fire			
Big Bend gambusia	*Gambusia gaigei*	Federal E, State E	Clear, shallow warm spring-fed natural pools and marshes. Fires may reduce cover, feeding and overstory shading habitat . Avoid removing all habitat around ponds; avoid burning synthetic material in boardwalk over habitt.
Texas horned lizard	*Phrynosoma cornutum*	Federal SOC, State T	Common in open habitat of desert scrub with little flammable material. Full distribution unknown.
Texas hornshell	*Popenaias popei*	Federal SOC	Studies by NPS, contractor, and Texas Parks and Wildlife in have revealed only dead shells, no live specimens. Dams, water release patterns, low flows due to agricultural use, and resultant increases in salinity have adversely impacted Texas hornshell. Fire used in conjunction with control of salt cedar may increase surface flows and improve water quality.

Status:
SOC = Species of Concern
E = Endangered
T = Threatened
DC = Under Delisting Criteria
Ex = Extirpated

Sources:
Texas Parks and Wildlife Division update from Austin office July 2004.

Plants
Vegetation of Big Bend was introduced under impact topic 4. The park is extraordinarily diverse with 1200 plant species, approximately 120-130 of these rare or endemic to the park. Staff identified 33 federally listed species for consideration under the fire program in Table III-2. Federally listed plant species in the park include Bunched Cory cactus (*Coryphantha ramillosa*), Chisos Mountain hedgehog cactus (*Echinocereus chisoensis* var. *chisoensis*), Lloyd's Mariposa cactus (*Sclerocactus mariposensis*), and Hinckley's oak (*Quercus hinckleyi*). Guadalupe fescue (*Festuca ligulata*) is a candidate species. Only the Chisos Mountain hedgehog cactus is likely to be adversely affected by the activities under consideration for the new FMP and is being formerly assessed under a U.S. Fish and Wildlife Service Biological Assessment concurrently with this EA. There are 12 species whose habitat consists of rocky ledges and sparsely vegetated areas and unlikely to be affected by fire; 14 species are considered tolerant of fire; local populations of 2 species could be affected by high-severity fire; and 5 species are very rare and high-severity fire could kill the entire population. The candidate species Guadalupe fescue is measured under a conservation agreement with the U.S. FWS dating from 1998.

Staff are concerned and interested in the many rare plants- at least 120 species. So little is known about the lifecycle, location, and number of many of these plants that they cannot yet be included in a federal listings program. To remedy this situation, staff are continually updating GIS databases with new locations and are gradually gathering information about the life cycle of these plants, recognizing that the public rely upon the park for their long-term conservation.

Fire has occur here (Moir 1982) and will occur in the future. Its intermittent occurrence may be a reason for the current plant diversity. Presumably, plants experienced some level of fire in the past but possibly not the high-severity fire possible under current fuel loads. Staff have created the safeguards below to lessen possible adverse effects from fire. These are:

- Evaluate fire effects and fire dynamics of selected species and habitats using research burns, the results guiding introduction of prescribed and natural fire in the Chisos.
- Allow natural ignitions within prescriptions (low and moderate intensities) to reduce fuels. Low intensity fire lessens damage to plants and is thought to mimic pre-European fire.
- Monitor all prescribed fire (and natural fire if possible) to fine-tune prescriptions allowing modifications to enhance the protection of plant species if needed.
- Suppress all fires burning outside prescriptions.
- Select locations of staging sites, natural firebreaks and spike camps prior to fires to avoid unnecessary ground disturbance from containment and suppression activities. These locations have been selected under the emergency evacuation
- Continue adding location and life history data of rare, threatened and endangered plants to a GIS database.

Special species and expected fire effects
Castilleja elongata- Tall-Stemmed Paintbrush
USFWS – candidate
Highly visible reddish bracts emerge with summer monsoons. Found in open woodlands, grasslands, and along trailsides at moderately-high elevations with Coahuila scrub oak, pinyon ricegrass, pinyon pine, mountain mahogany, and with alligator juniper at high elevations. Found in fire tolerant habitats and expected to survive low intensity burns outside the growing season. The plant is browsed by deer, in danger of being overcrowded by shrubs, soil erosion and from trampling in heavy use areas. Reduction of woody vegetation with prescribed burns may benefit this species.

Coryphantha ramillosa – Bunched Cory Cactus
USFWS - threatened
Large pink to purple flowers have attracted cactus poachers. Found on limestone foothills ledges and crevices of limestone with lechuguilla, candelilla, leatherstem, yucca, ocotillo, prickly pear, and dog cholla. Restricted to the Boquillas Formation and Santa Elena Limestone (2500-3500 ft) in the park but also occurs in SW Terrell and Coahuila, Mexico. Rock crevices provide refuge from low intensity fires.

Echinocereus chisoensis var. chinsoenis - Chisos Mountain Hedgehog Cactus
USFWS threatened
A cactus endemic to the park and found on alluvial flats of well-developed desert pavement with creosote, lechuguilla, ocotillo, leatherstem, sea urchin cactus, and dog cholla. Often present under or within a nurse plant at elevations of 2250 ft. Dark green stem and white cottony material present when flowering attracts cactus poachers. Expected to fire except where buffelgrass has invaded habitat.

Festuca ligulata – Guadalupe fescue
USFWS – candidate
Rare perennial grass from 14-30 inches occurring at 6000 ft on gentle, forested slopes in canyon bottoms with oak and pine overstory. Managed under a conservation agreement with the USFWS since 1998. Moir (1996) estimates that 155 years have passed since a low-intensity fire burned through this area. Most grasses are fire adapted resprouting from the base following fire. Current low seedling establishment may be due to high duff levels preventing seed contacting mineral soil. Very small research burns are proposed to examine seedling recruitment in mineral soils.

Sclerocactus (Neolloydia) mariposensis- Lloyd's Mariposa Cactus
USFWS threatened
Found on arid, gravelly, limestone-derived soils on gentle slopes, primarily on the Boquillas Formation in sotol-lechuguilla shrublands at elevations of 2,500-3,500 feet. Cactus poachers have decimated populations outside the park but populations are quite numerous in some areas (Anderson and Schmalzel 1997). Fire occurs in these formations but low fine fuel loading result in localized and low intensity fires.

Plants listed as threatened or endangered in Texas
Agave glomerulifolia – Chisos Agave
Species of Concern
An agave with flowers raceme on a 5-6 m stalk. Found in grasslands of the Chisos Mountains with pinyon pine, juniper, and bull muhley. Fire tolerance depends on fire intensity and size of plant, with larger plants more tolerant than younger plants. Chisos agave is also at risk of being inadvertently destroyed by maintenance activities along trails and roads. Mature Palmer's agave was found to better withstand fire than juveniles and seedlings or young offshoots (Howell 1996; Johnson 2001).

Andrachne arida – Trans-Pecos Maidenbush
Species of Concern
Rare shrubs less than one meter found on limestone slopes, canyons and crevices mostly in the Dead Horse Mountains, NW of Solitario Peak in Black Gap and in Coahuila, Mexico. Distinguished by greyish-white leafy twigs. Occurs in dry conditions little available fuel to carry fire. Not expected to be affected by the fire program.

Aquilegia longissima –Long-Spur Colombine
Species of Concern
Up to a meter tall with conspicuous yellow flowers. Found in moist canyons among boulders on ledges and sheltered crevices in canyons with species of oak, bigtooth maple, Mexican buckeye, drooping juniper, and evergreen sumac. A mesic species that is unlikely to tolerate fire. Seed stored in soil may

facilitate post-fire recovery. Low to moderate intensity fires in normal fuel loads creating mosaics of burned and unburned vegetation is unlikely to adversely affect populations.

Batesimalva violacea – Purple Gay Mallow
Species of Concern
Slender erect shrub to 2m with blue-purple flowers. Found among boulders and rubble in moist canyons with species of oak, Texas persimmon, Mexican buckeye, evergreen sumac, and fragrant ash. Expected to be fire tolerant as conspecific vegetation is fire tolerant.

Bonamia ovalifolia –Bigpod Bonamia
Species of Concern
Flowers on this low forb are blue-purple and bell-shaped. Found in sand and among boulders, and also found in sandy drainages along roadside. Subject to trampling by humans on dunes and its habitiat invaded by buffelgrass. Buffelgrass would increase the flammability and heat of any fire with unknown effects on the Bigpod. There are plans to remove buffelgrass from around known populations.

Brongniartia minutifolia – Littleleaf Brongiart.
Species of Concern
Endemic to the park and found in arroyos, blackish sandy soil and perhaps limestone. An attractive shrub about one meter high with small leaflets and yellow-green flowers. Fire effects unknown.

Chamaesyce golondrina – Swallow Spurge
Species of Concern
A prostrate, hairy annual herb with non-showy flowers found on alluvial desert soils. Fire effects unknown but found in areas with discontinuous fuels.

Chamaesyce chaetocalyx var. *trilulata* – Three-Tongued Spurge
Species of Concern
Endemic, perennial to 15 cm only found in crevices of limestone cliffs above entrance to Boquillas Canyon from 3000-3500 ft in elevation. Occurs where it is unlikely to be at risk from fire.

Coryphantha chaffeyi – Chaffey's Cory Cactus
TPWD –Threatened
White flowered cactus found on rocky igneous or limestone areas in open areas or under trees. In the Chisos Mts. from (5800-7000 ft). Inadvertantly destroyed by hikers, trail maintenance, and some poaching. Limited fuels means this cactus is likely to escape fire effects in open areas.

Coryphantha dasyacantha – Dense Cory Cactus.
Species of Concern
Found on rocky/gravelly igneous soil of desert scrublands; may also occur in limestone derived soils in woodland and grassland into the desert from 3400-3800 ft. Pink flowers. May also occur in Mexico. Limited fuels mean that fire effects are likely to be localized.

Coryphantha duncanii – Duncan's Cory Cactus
Species of Concern
This pink flowering cactus is found in crevices of limestone shelves at elevations between 2100-2625 ft in the park and slightly higher in New Mexico. Threatened in NM from habitat disturbance. Occurs in sparsely vegetated habitat within Big Bend suggesting that the cactus is likely to escape fire in the park.

Coryphantha albicolumnaria –White Column Cactus
Species of Concern
Conspicuous radial spines that whiten with age and rose-pink to magenta flowers. Found on broken limestone and on rocky alluvium with creosote, lechuguilla, candelilla, dog cholla, skeletonleaf goldeneye, leatherstem, false agave, and resurrection fern at elevations between 1900 and 4800 ft dispersed over Texas and New Mexico. Subject to poaching and damage from mine closure activities. Amount of understory fuels, shrub cover, and wind speed would determine likelihood of fire damage.

Hexalectris nitia – Glass Mountain Coral Root
Species of Concern
Small shiny purple flowers that bloom one at a time. Found among rocks in shaded canyons with abundant pinyon-oak-juniper leaf litter. Occurs in areas with oaks, which resprout after burning so may withstand or regrow from roots following fire.

Hexalectris revoluta – Chisos Coral Root
Species of Concern
Perennial from 30-40 cm high found in moist or dry oak woodlands in mountains at 4,500-5,200 ft. Grows under edge of oak trees in canyon bottoms and on slopes between boulders. Blooms June through July. Boulders would provide some shielding from fire; plants in drainage bottoms likely to be consumed by fire but may resprout from roots as they occur with oaks tolerant of fire.

Hexalectris warnockii –Texas Purple Spike
Species of Concern
Smooth maroon stem with large nodding showy flowers veined with purple, adorned with orange-yellow lamellae and purple at the apex. Found in shady juniper-oak woodlands above 5900 ft. Occurs in areas which probably experienced fire in the past; fire tolerance unknown.

Lechea mensalis – Chisos Pinweed
Species of Concern
Inconspicuous, tall, straight perennial herb found in pinyon-juniper country and the wooded summit of Mt. Emory in 1992 and on ridge exposures of Ward Mountain (1966). Fire effects unknown but occurs in aras that have experienced fire in the past.

Opuntia aureispina- Golden-Spined Prickly Pear
Species of Concern
Found on limestone hills near the Rio Grande from Mariscal Mountain to Boquillas Canyon. Distinguished by yellow spines and yellow flowers with red centers and dry, tan spiny fruits. Occurs in areas with little vegetation but buffelgrass is invading and would increase fire intensity. Pads surviving fire reestablish.

Opuntia imbricata var. argentea – Silver-Spine Cholla
Species of Concern
Distinguished from tree cholla by silvery spines. Found on gravelly and sandy soils in the park with little understory. May be damaged in high wind driven fire or where buffelgrass has established underneath.

Ostrya chisoensis – (*Ostrya virginiana* var. *chisoensis*). Big Bend Hophornbeam.
Small trees to 12 meters found 5,000-8,000 feet in canyons and slopes north of Emery Peak; Crown Mt; and Boot Springs. Fire tolerance unknown but occurs in areas where fire has occurred.

Quercus tardifolia –Chisos Mountain Oak
Species of Concern
Short, dense trees with thick bark in woodlands at 7,000 ft along arroyos in the Chisos and canyon bottoms in shaded, igneous soil. Found between Boot Spring and South Rim and Upper Boot Canyon. Fire tolerance unknown but most oaks resprout from roots or under bark following low-intensity fire.

Quercus graciliformis – Chisos or Slender Oak
Species of Concern
Endemic small evergreen trees to 8 m or more with graceful, arching, slender branches. Usually found in rocky canyons with high water tables such as Juniper Spring and Blue Creek Canyon. Fire tolerance unknown but most oaks resprout from roots or buds under bark following fire. Likely to survive low intensity fire.

Stenaria mullerae var. pooleana – Houstonia pooleana
Species of Concern
Perennial 3-4 cm x 5-10 cm wide found on vertical limestone cliff faces in the Dead Horse Mountains. Associated plants include agave, lechuguilla, oaks and rhus spp. Collected in 1987 at 4840 ft. Probably experienced infrequent low intensity fire. Might be consumed by high intensity fire with long-flame lengths if sufficient vegetation established below cliffs.

Streptanthus cutleri – no common name
Species of Concern
This annual is a member of the mustard family growing from a vertical taproot to 20-70 cm. It is found where there is little competition on talus slopes, gravelly dry streambeds, limestone slopes, rocky hillsides and sand flats. Flowers March through April with a dark purple flower followed by 4-7 cm long fruits. Occurs where there are few fine fuels to carry fire

Table III-2: Sensitive Plant Species under all Alternatives

Common Name	**Scientific Name**	**Status**	Habitat
Species occurring on rocky ledges or in other areas relatively protected from fire:			
Bunched cory cactus	*Coryphantha ramillosa*	T-F	Limestone crevices and ledges on low hills associated with the Rio Grande corridor
Chisos Mountain hedgehog cactus	*Echinoceres chisoensis var. chisoensis*	T-F	Alluvial flats of desert pavement in southeast portion of the park
Cutler's twistflower	*Streptanthus cutleri*	SOC-F	On talus slopes, gravelly dry stream-beds, limestone slopes, rocky hillsides and sand flats
Duncan's cory cactus	*Coryphantha duncanii*	SOC-F	In crevices on limestone shelves
Golden-Spined prickly pear	*Opuntia aureispina*	SOC-F	On limestone hills
Lloyd's Mariposa cactus	*Sclerocactus mariposensis*	T-F	Gravelly limestone derived soils
Silver-Spined cholla	*Opuntia imbricata var. argentea*	SOC-F	Gravelly and sandy soils mostly in desert scrublands
Swallow spurge	*Chamaesyce golondrina*	SOC-F	Alluvial desert soils
White column cactus	*Escobaria albicolumnaria*	SOC-F	Broken limestone and rocky alluvium.
Trans-Pecos maidenbush	*Andrachne arida*	SOC-F	Limestone slopes, canyons and crevices
Three-Tongued spurge	*Chamaesyce chaetocalyx var. triligulata*	SOC-F	In limestone crevices at entrance of Boquillas Canyon at 3,000-3,500 ft
Two-Bristle rock daisy	*Perityle bisetosa var. bisetosa*	SOC-F	Pockets and crevices of limestone rock
Species whose local populations might be affected by a high-intensity fire:			
Chaffey's cory cactus	*Escobaria var. chaffeyi*	SOC-F	Rocky igneous or limestone in open areas or under trees at 5,000-7,000 ft
Dense cory cactus	*Escobaria dasyacantha var. dasyacantha*	SOC-F	Rocky igneous soils of desert scrublands, and limestone soils of woodland and grasslands
Species whose entire known population might be affected by a high-intensity fire in USA:			
Bigpod bonamia	*Bonamia ovalifolia*	SOC-F	Sand dunes, among rocks in dunes, along roadsides and in Boquillas Canyon. One population at risk due to growth of buffelgrass. Three populations of a total of five globally
Chisos hophornbeam	*Ostrya chisosensis*	SOC-F	In heavily timbered canyons and on slopes 5,000-8,000 ft north of Emory Peak

Common Name	**Scientific Name**	**Status**	Habitat
Chisos Mountain or Lateleaf oak	*Quercus tardifolia*	SOC_F	One plant known in Boot Canyon; more in Mexico in wooded canyon bottoms and arroyos
Guadalupe fescue	*Festuca ligulata*	C-F	Canyon bottoms with oak and pine overstory
Tall-stemmed paintbrush or Squawflower	*Castilleja elongata or C. integra var. integra (taxonomy questionable)*	C-F	Perennial growing on the wooded slopes of the Chisos
Species occurring in fire-prone habitats that are likely to be fire tolerant:			
Chisos agave	*Agave glomeruliflora*	SOC-F	Chisos grasslands with pinyon pine, juniper and Bull muhley
Chisos coral root	*Hexalectris revoluta*	SOC-F	Moist or dry open oak woodlands in canyons, among boulders
Chisos Pinweed	*Lechea mensalis*	SOC-F	Found in pinyon-juniper country, wooded summits and rocky exposures
Glass Mountain coral root	*Hexalectrus nitida*	SOC-F	In shady canyons among rocks with pinyon-oak-juniper leaf litter
Little-leaf brogniartia	*Brogniartia minutifolia*	SOC-F	Arroyos, blackish sandy soils and perhaps on limestone
Puckering nightshade	*Nectouxia formosa*	Not formally petitioned for federal listing	Found in woods, and meadows in mountains at high elevation 6,500-8,000 ft on limestone, clayey and sandy soils
Texas purple spike	*Hexalectris warnockii*	SOC-F	Shady juniper-oak woodlands
Long-spur colombine	*Aquilegia longissima*	SOC-F	In moist soils along drainages in wooded and forested areas including Maple and Pine Canyons and Cattail Falls
Purple gay mallow	*Batesimalva violacea*	SOC-F	Moist canyons among boulders with mesic overstory
Slender oak or Chisos oak	*Quercus graciliformis*	SOC-F	Rocky canyons with high water tables
Texas largeseed bittercress	*Cardamine macrocarpa var. texana*	S2	Limited distribution in mesic pinyon-oak-juniper woodlands. Associated with Guadalupe fescue
Sierra del Carmen oak	*Quercus carmenensis*	S1	Occurs near peak of Casa Grande Mountain in fire prone area
Harvard's stonecrop	*Sedum harvardii*	S2	Grows out of bedrock in mountains, which have experienced fire in the past
Robert's stonecrop	*Sedum robertsianum*	SOC-F	

Status:
T-F= Federal Threatened
C-F= Candidate for Federal Threatened or Endangered
SOC-F= Federal Species of Concern

Rank (Texas)
S1= Less than 6 occurrences know in Texas; critically imperiled in Texas; especially vulnerable to extirpation
S2= 6-20 known occurrences in Texas; imperiled in the state because of rarity; very vulnerable to extirpation
SH= historical in Texas; not verified within the past 50 years but suspected to be extant

Sources:
International Plant Names Index. Web Site: http://www.ipni.org/index.html
National Plant Data Center. Web Site: plants.usda.gov.2002
MGB.W3Tropicos. Missouri Botanical Gardens Nomenclature Data Base. Web Site: http://mobot.mobot.org/W3T/Search/vast.html
Texas Parks and Wildlife. Web Site: http://www.tpwd.state.tx.us/native/endang/ List of the rare plants of Texas, June 2003, June 2004.
Poole, Jackie, Singhurts, Jason, Price, Dana and William Carr. A List of Rare Plants of Texas, TPWD, Austin and Texas Conservation Data Center, The Nature Conservancy of Texas, San Antonio. January 2002.
Synthesis of North American Flora – A computer database by John Kartez & Christopher Meacham. http://www.bioone.org/bioone. Restricted access.
Correll , D.S and M.C. Johnson. 1970. Manual of the Vascular Plants of Texas. Renner: Texas Research Foundation.

Impact Topic (6): Cultural Resources

Historic Context

In historic times, six countries have claimed the Big Bend as theirs but archeological sites suggest many ethnic groups have long used the region, gathering food plants, hunting, trading, and farming along the river. Each successive group to enter and colonize the region met conflicts with previous inhabitants. The Treaty of Guadalupe Hidalgo of 1848, opened the area as U.S. territory and lead to an influx of Euro-Americans bent on exploration, exploitation of the natural resources, and settlement. Conflicts with American Indians who already occupied the land lead to the decimation of Indian populations. The opening of the railway along the San Antonio to California trail in 1882, and changes in landowner laws opened the way for Europeans to ranch, and farm in the Big Bend. Homesteads, corrals and fencelines, and watering points from this period are still in use on modern ranches outside the park, and inside the park, have become attractions for visitors wishing to understand the park's history. In the 1930s, Roosevelt's new deal and the "CCC" era has left rustic stone work along the Chisos Basin Road and several trails in the Chisos Mountains.

The remnant sites, structures, and buildings from these historic periods are important resources which the park preserves for the enjoyment of the visiting public. Historic structures, cultural landscapes, and artifacts may incur fire damage, while fire may be used to help reduce surrounding hazard fuels and maintain historic landscapes and views. Below is a compilation of known resources in the park from NPS surveys in 1936-37, 1966-67, and post 1982. There are currently more than 1560 sites in a cultural site database at the park, and new sites are added as they are found. Under the proposed alternative, cultural resource surveys are required prior to prescribed fire activities. Pre and post-fire monitoring by professional archeologists for prescribed burns would identify additional archeological sites. Post-fire monitoring of natural ignitions also would identify additional cultural sites. A Cultural Resource Component was developed as part of the park's resources and is listed as Appendix C.

Park Resources

Archeological resources

Based on a NPS system-wide Archeological Site Estimation Project in 2002, the NPS has estimated that Big Bend National Park contains 26,000 archeological sites dating from 8000 B.C to about 1535 A.D (GMP, 2003). Additional funding has not been available for formal surveys but as sites are found they are inventoried on a GIS database. Two archeological sites and one archeological district (Burro Mesa) are listed on the National Register of Historic Places, with another site and the Glenn Springs Cavalry Outpost in the process of nomination. Fifteen sites are State Archeological Landmarks. These sites should be top priority for protection against wildland fire though appropriate methods.

Historic structures

There are 69 structures on the List of Classified Structures with 49 of these on the National Register of Historic Places (NRHP). These 49 are within 8 National Register Districts or Sites. These sites or districts are Burro Mesa Archeological District, Castolon Historic District, Hot Springs Historic District, the Mariscal Mining District, the Homer Wilson Blue Creek Ranch Site, Rancho Estelle (Sublett Farm), Daniel's Farmhouse and Luna's Jacal. Three other sites are being nominated, many others evaluated and preserved as time and resources permit. Of the 69 listed structures for eligibility, 26 are in good condition. There are approximately 400 additional unlisted and unevaluated structures for which preservation management strategies are undeveloped. These must be protected until which time they can be formally documented, evaluated for National Register stafus, and management strategies can be developed.Throughout the park, forbs, succulents, shrubs and trees have grown around a number of historic structures and increase their flammability. Upon review by the cultural resource specialist and the fire ecologist a program of fuels reduction should be undertaken to meet the historic needs and also to allow for natural ignitions wherever possible.

Potential cultural landscapes

Cultural landscapes contain physical evidence of the full spectrum of human use,including aboriginal hunting and gathering by American Indians, Spanish colonial/military and exploration, European and American settlement, , military encampments, ranching, farming and agriculture, and mining. The NPS has determined that eleven landscapes are eligible for inclusion on the National Register of Historic Places. These are Castolon Valley, Terlingua Abajo, Boquillas Valley, San Vicente, Chisos Basin, Mariscal Mining District, Comanche Trail, Cottonwood Creek Valley, Glenn Spring, Neville Spring, Johnson Ranch. An additional eight landscapes have potential for listing in the National Register, but futher research is needed to identify boundaries and cultural relationships. These are Dugout Wells, Indian Head Mountain, La Noria, McKinney Spring, Government Spring Ranch, Hannold Ranch, K-Bar Ranch, and Tornillo Flat. An additional 48 landscapes or landscape-related elements are identified, but further research is needed to better understand these resources. These sites are threatened with neglect and effects of erosion, weathering, vandalism, flooding, collectors and collapse due to insufficient funding for repairs. Effects of vegetation and vulnerability to fire must be evaluated on a case-by-case basis. It is debatable for ecological reasons whether the denuded grazed or mined areas should be reestablished.

Ethnographic resources

During the prehistoric, the land was occupied by various huntering and gathering groups, and only in the Late Prehistoric has there been recorded identifications of these people. Spanish mission priests during the 1600s noted that the people occupying the area now in the park as the Chizo, a group of loosely associated bands that took the name of their respective leaders. Historic records indicate that other American Indian groups used the region either occasionally or seasonally and some of these groups still exist as federally recognized tribes. The park actively consults with seven of these tribal entities due to their ethnographic links to park resources. They are the Apache Tribes of Oklahoma (including the Lipan Apache), Comanche Tribe of Oklahoma, Kickapoo Traditional Tribe of Texas, Kiowa Tribe of Oklahoma, Mescalero Apache Tribe, Blackfeet, and Ysleta Del Sur Pueblo. The Crow Chapter of the Native American Church requested permission to use resources from the park in the 1970s and in 2003 the Ute Mountain Ute Tribe made plant gathering inquiries. Also in 2003, a group representing the and Mescalero and Lipan Apaches carried out a gathering of plants for ceremonial use. Other requests are expected in the future and these requests may influence fire actions in localized areas. Fire and fire related activities have potential to significantly affect plant resources and sites with which these groups hold ethnographic ties.

Additionally, six different governments have controlled the park– Mexico, Spain, France, The Republic of Texas, the Confederate States of America, and the United States of America. Various groups of European Americans, African Americans, Hispanic Americans, and Mexicans have familial or ethnic links to park resources.

The Fire Program and Cultural Resources

The size of the park, and the need for compliance and routine documentation consumes the majority of staff time of the one cultural resource specialist in the park. What is needed is a systematic approach to assessing and managing the parks cultural resources. The challenges are the potential number of yet-to-be-discovered sites (as many as 26,000 sites may exist in the park) and the specialized surveys needed to assess historic buildings, artifacts, archeological sites, and cultural landscapes to understand how they should be treated and maintained. This represents hundreds of sites requiring careful mapping, documenting of flammable materials and devising specific treatments for each site. Some general precautions can be applied to protect combustible materials such as glass, ceramic, metal or timber. Cultural landscapes are more prone to damage from suppression actions and erosion, which changes drainage and vegetation patterns. Without trained operators and supervision, fire crews cannot be expected to maintain these sites to National Register standards.

The Fire Management Officer and the Cultural Resource Specialist have taken steps to meet joint needs. The fire program currently pays for pre-burn cultural resource surveys. This is appreciated but skews CR work by consuming staff time to insure that surveys identified vulnerable sites, which must then be protected during fuel reduction burns. Rather than having the fire program conduct activities which meet cultural resource management needs, the fire program drives the CR compliance process. In response, the cultural resource specialist has developed a matrix for identifying sites and processes for reducing fuels that includes tools used by the fire program. As time permits the CR specialist will add to this list, providing the documentation for fuel reduction at particular sites, some of which may be undertaken by the fire program. The Fire Management Officer is attending natural and cultural resource meetings to understand how the fire program can serve these priorities within the park. Bi-annual or annual review of the fire program provides the opportunity for including fuel reduction of cultural resource sites in the fuels treatment roster.

Impact Topic (7): Watershed Effects.

Two ecosystems have been considered for erosive impacts of thunderstorms following fire; (1) the Chisos Mountains, and (2) the gently sloping flats of degraded desert grasslands in the east and northeast of the park.

High Chisos Watersheds

The Chisos Mountain watershed area is defined by the tops of the mountains down to the following roadways and trails: Park Route 13 to the north; Park Route 15 or Ross Maxwell Scenic Drive on the west, Park Route 12 from Panther Junction to the east; Glenn Spring Road and Juniper Canyon Road on the southeast; and Dodson Trail defines the southern boundary. These roads and trails truncate the watershed but are where most severe fire effects could occur and are part of the designated firebreak system.

The main threat to the Chisos is from high-severity fire, which could occur under extreme conditions in heavily wooded areas. High-severity fire burns soil organic matter predisposing it to movement if followed by intense summer thunderstorms. Grasses are burned to below ground, soil seed reserves destroyed, and shrubs and trees scorched or killed depending on the species and depth of the root callus. Watersheds most at risk are higher elevations at the northern end of the Chisos Mountain Range covering approximately 20,000 acres. Watersheds within this area are; Oak Creek Canyon (3,800 acres), Boot Canyon (845 acres), Upper Pine Canyon (3,040 acres) and Upper Cattail Canyon (1,490 acres). Elevation ranges from 4,200 to 7,832 feet. Soils in these canyons are formed primarily on igneous rocks and are well drained, moderately permeable and provide for rapid surface runoff. Slopes are convex to plane, steep and are mostly 20 to 45 percent although they range from 8 percent to near vertical. Erodability ranges from moderate to severe depending on slope and the presence of coarse material. Erodability in Oak Creek Canyon is severe due to steep slopes and fine-grained material. Proximity to developed areas and areas with high visitor use are a concern. Upper Pine Canyon is the subject of long term intensive studies designed to determine the impacts of pollutants and climate change on watershed dynamics. Slick rock conditions currently exist in Boot Canyon with running water present much of the year. Soil and debris movement from the slopes above could cover and eliminate this important wildlife water source until the material is exported from the canyon. Soil movement into Cattail Canyon likely could become choked among large boulders and build up at the bottom of very long drops.

Tornillo Creek and Nine Point Draw Watersheds.

It was the grasslands that attracted ranchers to the Big Bend and changes in landowner laws that made their enterprises possible. Free from grazing for 60 years, grasses have recovered in the high desert but not on the drier, less permeable flatter slopes to the north and east of the park (Maxwell, 1994). Satellite imagery shows shrub encroachment into desert grasslands south of Persimmon Gap (McKernan 2003) **-**

an expected outcome in droughty soil conditions from increased runoff and reduced competition (Cable 1975), and low litter production (Maya and Arriga 1996). McKernan's thesis however, points to the possibility of increasing grasses in the area when burns are followed by above average precipitation and seed sources are available. Harvstad (1996) counters this optimism by pointing to poor or no recovery of black grama once shrub cover is established following decades of intermittent drought and grazing recovery. The fire return interval for maintaining desert grasslands in semi-arid areas using fire is 7-10 years (McPherson 1995) with the U.S. Forest Service FEIS web site suggesting from 35-250 years in arid areas with slow biomass accumulation. Small research burns may aid restoration under conditions of above average rainfall, with soil stabilization and suitable seed sources.

Nine Point Draw (approximately 90,000 acres) and Tornillo Creek (approximately 75,000 acres) are at risk from the effects of intense thunderstorms especially after fire removes sparse vegetation. These two watersheds encompass all the lowland desert in the north end of the park as well as much of the east portion of the park. Slopes are almost level and finely textured soils derived from both igneous and carbonate rocks have slow infiltration leading to overland flows and gully erosion. Ranching and farming activities, especially in the Nine Point Draw watershed, have left large areas denuded. Eight to ten inches of soil depth have been lost over large portions of each watershed and wide gully systems are advancing across each. Grasslands are fragmented. The beneficial effects of fires in grasslands may not apply to highly degraded desert grasslands.

Attempts have been made to rejuvenate the tobosagrass flats at Tornillo Flat in the 1950s by the Soil Conservation Service. Mechanical methods aimed at increasing infiltration brought a sodic layer to the surface preventing tobosagrass from establishing (Jeffery Bennett, personal communication Septmber 2004). Elsewhere, staff are concerned about overland flows further removing soils and hampering recovery of any vegetation. They are cautious about embarking on a fire program that may cause type conversion of desert grassland to scrub desert or the reverse, or result in the loss of fire intolerant species over time. For these fragile areas they intend small-scale experiments to determine which strategies are most successful at extending grasslands where they currently exist, and where they are known to have occurred historically.

Impact Topic (8) Resource Support for the Fire Program

Allowing more fire on the landscape and conducting research burns will require more monitoring of pre-fire and post-fire effects and additional vehicles, fuels, and trained staff.

The Review and Update of the 1995 Federal Wildland Fire Management Policy, January 2001 calls for appropriate levels of preparedness that …will ensure their [agency's] capability to provide safe, cost-effective fire managment programs in support of and resource management plans through appropriate planning, staffing, training, equipment, and managment oversight."

Currently the park has the capacity to handle a remote wildland fire requiring multiple resource types (engines, crews, aircraft) and with limited potential to spread toward values at risk. A wildland fire threatening a public development area and with potential to spread for multiple days is beyond the park's capacity to control. Generally, the park has the resources to conduct initial attacks on unplanned ignitions but needs to call on outside resources for extended attack fires. Key positions such as Engine Boss and Crew Boss lack sufficient qualified personnel on the park staff. This lack of qualified leadership limits the park's ability to activate every Big Bend firefighting resource fully and effectively.

The park anticipates needing to train more personnel to conduct pre-fire and post-fire monitoring of research burns, and engage specialist trainers to train park staff in burning under hazardous conditions. The Fire Management Officer is seeking additional recruitment and training of Los Diablos participants under the new FMP, to meet new standards for fire crews. Specialized training is sought for Los Diablos members to handle hazards of high fuel loads in rugged terrain such as the Chisos. Pre and post-fire monitoring of research burns requires additional protocols to meet specific design criteria and may continue for considerable time to obtain scientifically useful data. A new staff position, Fuels Specialist is sought to assess fuels across the park, develop and apply research protocols, and investigate the spectrum of hazardous fuel reduction measures to meet threatned and endangered species protection, rare species, cultural resources and effective prescribed burns in particular vegetation types.

The proposed changes for the new FMP are to provide a research platform for allowing staff to learn how to allow fire to resume its natural ecological role, and in so doing contribute to ecological sustainability in harmony with the Federal Wildland Fire Management Policy, January 2001. Funding however, is oriented towards suppression of emergency wild fires and fuels reduction through prescribed burning, and less towards supporting routine fire operations such as natural ignititons and reserach burns that would safely allow fire to resume its role in the Big Bend landscape.

Suppression has been the primary response to fire under the current (1994) FMP and park needs have been met by existing staff and resources in Table IV-1 below. The proposed alternative will allow more fire in the park and fires may burn larger, longer, and more frequently than before. Depending on the frequency of fires, fire size and intensity, and regional preparedness levels, the park may experience challenges in meeting resources for additional monitoring, suppression, and specialized research burns.

Table III-3: Current Fire Program Resources

Resource Type	Number	Location	*Response Time	Availability
Type 6 Engine (863)	1	Panther Junction	0.5 hours	Year-round
Type 6 Engine (864)	1	Panther Junction	0.5 hours	Year-round
Seasonal Firefighters	5-16	Through-out park	0.5 – 3 hours	Fire Season only
Type 1 Engine (811)	1	Panther Junction	0.5 hours	Year-round
Type 1 Engine (812)	1	Chisos Basin	0.75 hours	Year-round
Type 1 Engine (821)	1	Rio Grande Village	1.0 hours	Year-round
Type 6 Engine (865)	1	Castolon	1.5 hours	Year-round
Type 6 Engine	1	Terlingua	1.5 hours	Intermittent
Regular Firefighters	10-15	Through-out park	1 – 3 hours	Year-round
Cessna N104PS	1	Harte Ranch	1.5 hours	Pilot dependent
Trailer Unit	1	Rio Grande Village	2.0 hours	Year-round
Mules	6	Panther Junction	2.0 hours	Year-round
Type 6 Engine (TxFS)	1	Fort Stockton	3.0 hours	Intermittent
Los Diablos Firefighters	39	Mexican Villages	3.0 hours	Year-round
Type 3 helicopter	1	Mescalero Apache	4.0 hours	Fire Season only (90 day contract)
Type 3 Incident Mgmt Team	1	Lincoln Zone	6 – 8 hours	March thru July
Type 2 Incident Mgmt Team	1	New Mexico	24 hours	March thru October

*Response time is the time required to travel to Panther Junction and be ready for work.

Implementation
To implement Alternative C there will be additional requirements for planning, monitoring, resource advice, and compliance in addition to increased demand for general operations staff time and resources.

Planning & Compliance
The proposed 10-year fuels treatment program will need additional staffing to complete the planning and compliance workload. A recent analysis of the fuels program workload recommends a Prescribed Fire Technician; a position not currently funded and is not currently designed with the training, skills or knowledge to complete planning and compliance requirements. To date, planning and compliance duties are distributed among current staff. These planning and compliance duties have been and will be the future bottleneck to meeting annual targets. The fire staff recommends adding a Prescribed Fire Specialist for planning and compliance duties to meet the needs of the proposed fuels treatment program.

Monitoring
The current monitoring staff is under funded and deficient in employees needed to accomplish the monitoring workload. There is one permanent employee for monitoring. An analysis of workloads for fire effects monitoring suggests the need for two additional permanent employees Fire Effects Module Leader, and FE Module Assistant Leader and two seasonal FE Monitor Crewmembers. The park has already begun transferring some monitoring and compliance work to the fire program from other resource areas allowing these programs to meet compliance goals. The fire program is currently surveying and monitoring areas for cultural resource objectives and for natural resource objectives. The proposed 10-year fuels treatment program is an increase in workload particularly for the careful monitoring required for fire effects and fire dynamics associated with research burns, and assessment of areas for rare species. The Fire Effects Module has responsibility for monitoring fire effects in the parks served by the Big Bend FIREPRO staff. The fuels treatment program workloads in these area parks will also increase in the future.

Key Additional Personnel
Wildland Fire Use (WFU) is an appropriate management response on some unplanned fire ignitions in both Fire Management Units and under Alternatives B and C. A WFU Team is required to manage wildland fire use incidents and a team will be an appropriate management response option when considerations such a prescription conditions, values at risk, cost-benefit and others make WFU the best management choice. The park staff is currently lacking in personnel qualified and trained in WFU skills. A Fire Use Manager Type 2 is the key deficient position. One park staff member is currently a trainee and should be encouraged to complete the qualification requirements. Prescribed Fire Monitors are also needed to manage these fires. The park has a history of Type 2 wildland fire use incidents.

Resource Advisors
Resource advisors will be required on an unplanned incident-by-incident or planned project-by-project basis. An example is an unplanned ignition occurs in the park. The potential for fire spread and expected fire effects is evaluated. Resource advisors from the park staff (archeologists, botanist, wildlife biologist and hydrologist) are consulted on what are the possible adverse impacts. With this input from resource advisors, an appropriate management response and fire strategy is put into place. This will be dynamic process and re-evaluation of the situation will take place on a daily or as-needed basis. There are insufficient fire-line qualified archeologists to provide potential fire-line impacts to un-surveyed areas for a multiple day incident. The incident managers should expect to request additional archeologists. Below in Table III-4 and Table III-5 are the staffing and training needs required by Big Bend's fire program to effectively meet the planning, compliance, monitoring, and fire fighting needs associated with the new fire program.

Table III-4: Additional Staffing Needs

Position	Grade	Position	Pay periods	#
Fire Crew Supervisor	GS-6	*Furlough	13	1
Prescribed Fire Specialist	GS-9	Permanent	26	1
Asst. FE Module Leader	GS-6	Furlough	13	1
FE Crew Member	GS-5	Temporary	12	2

Table III-5: Staff Traing Needs

Position	Grade	#
Fire Use Manager Type 2	FUM2	1
Crew Boss	CRWB	3
Engine Boss	ENGB	3
Prescribed Fire Monitor	MTNR	4

Legend
*Furlough – permanent employees funded less than a full year.
Temporary – seasonal positions without employee benefits
Grade – pay level scale for government positions

It is worth noting that 45,000 volunteer hours were given to the park in 2000 (BBNP Business Plan 2000) – a generous gesture that also suggests the park lacks the funds to hire permanent employees to address needed maintenance and routine tasks in various departments.

Preemptive Safety Measures
Recognizing the difficulty of controlling and suppressing fire in the Chisos under extreme conditions, the park has prepared measures to protect the public, and to engage them in keeping this area safe from careless misuse of fire. A carefully sequenced evacuation plan has been prepared for the Chisos Basin. High visitation and dry pre-monsoon conditions pose considerable hazards in the high Chisos. Hikers and visitors to the high Chisos will receive a warning of the fire danger on their hiking permit if the park believes the conditions severe. The park may also post a ranger at the beginning of the major trailheads during extreme conditions to warn people of the danger and to advise against smoking and lighting fires.

Under extreme conditions the Superintendent may close all public areas to smoking, open fires and even to hiking. Depending on the year, all of these precautionary measures will require additional staff during the main fire season from March through July. Staff are drawn from other divisions within the park to meet these periodic needs.

Chapter IV: Environmental Consequences

This chapter evaluates the environmental effects of the three fire management alternatives retained in Chapter II on the eight impact topics.

Methodology

This EA analyzes the effects of differing amounts of prescribed fire, wildland fire use, suppression, non-fire treatments under the three alternatives. Alternative A allows the least use of fire and poses the greatest risk of future wildland fires. Alternative B was developed with the understanding that fire shaped park vegetation. It is envisioned to reduce fuels over more of the park fastest, but possibly with some negative effects over the short-term. Alternative C curbs the possible negative impacts of Alternative B in sensitive habitats with the use of the Special Treatment Zone in the Chisos, and use of research burns in a variety of habitats and species where fire effects are not well understood. The Special Treatment Zone is a 'red light' to managers to pay special attention to natural and prescribed fire in the Chisos. Lightning ignitions may be allowed to burn in selected areas at low and moderate intensity. Prescribed burns will be guided in area, intensity, and habitat by research questions and protocols.

The three alternatives were the IDT's best attempt to satisfy NPS policy and the goals and objectives of Big Bend's fire program. In developing Alternative C, they found a balance between reducing immediate threats from high fuels and providing long-term information from research burns to improve future management decisions. Given the uncertain nature of fire, weather, and regional priorities and resources, the IDT cannot guarantee that the alternatives will have the predicted effects, and may even result in similar outcomes.

Environmental Consequences

Under NEPA, effects of alternatives are defined in terms of :

- *context* (are effects site specific, local or regional?) A site specific effect might be a decrease in population, a local effect might be erosion across a watershed, a regional effect might be at the level of entire ecosystems or landscapes across a mountain range.
- *intensity* (are the effects negligible, minor, moderate, or major, or would they lead to impairment of Big Bend's resources and values?) Definitions vary by impact topic
- *duration (*are effects short-term or long-term?) Short-term effects result in return to predisturbance condition or appearance within hours to the duration of the FMP. Long-term effects may exceed the duration of the FMP.
- *timing* (do the effects vary with the timing of alternative actions?*)* Prescribed fires are scheduled outside normal fire season and may impact some fire dependent species.
- *direct impacts (*are resources adversely or beneficially affected?) Adverse effects take a resource away from a desired condition or appearance. Beneficial impacts have the opposite effects.
- *indirect impacts (*do other adverse or beneficial outcomes occur from the action?)
- *cumulative impacts* are discussed in the next section, and
- *mitigative effects* are actions that reduce environmental effects of alternatives.

Cumulative Effects

Cumulative impacts are defined by the Council of Environmental Quality as "the impact on the environment that results from the incremental effect of action (s) when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) undertakes such action" (40 CFR 1508.7). Actions with a potential to add to the effects of the FMP were contributed by the IDT. They include:

- Development of walking trails (1) to connect Kibbe Springs along the south side of Casa Grande with the Lost Mine Trail, and (2) to provide a link from the Castolon historic area to the river.
- Construction of new buildings including several new houses or duplexes to replace old trailers, construction of a fire managment office, and enlargement of the visitor center –all at Panther Junction.
- Continued but slow growth in the western gateway communities of Study Butte and Terlingua, and the resort town of Lajitas.
- Fires on state and private lands adjacent to the park.
- Fire events at Big Bend preceding and following the term of the new FMP.
- Continued fuel accumulations in the Chisos.
- Expansion of nonnative plant species.
- Pilot revegetation of natives along riparian corridor.
- Past and future flood and erosion events.
- Defoliation of trees by caterpillers in the Chisos during periods of stress.
- Expanded interpretive and education programs.

Impairment Analysis
NPS is required by law (Organic Act, General Authorities Act) to guarantee that natural and cultural resources will be passed onto future generations unimpaired. Managers must seek ways to avoid, or minimize to the extent possible, actions that would adversely affect resources and values that are essential to the identity or purpose or part of the enabling legislation of the park. Each natural and cutural impact topic has NPS specific language. Impairment determinations were made with the judgement of professional staff and relevent studies.

Appendices
There are three appendices that provide supporting information for this chapter. They are Fire Effects on Dominant Plant Species (Appendix B), the Cultural Resources Component (Appendix C) which was prepared for evaluation by the Texas Historical Preservation Office, and a list of plant and animal species discussed thougout the text (Appendix D).

Impact Topic (1). Life and Property
Fire is an effective tool for reducing hazard fuels, but it is also a threat to the public, firefighters, park staff, developed areas, and neighboring properties.

The first and foremost objectives for fire management are the protection of life, property, and resources from the unacceptable effects of wildland or prescribed fire. Life and property encompasses park staff, firefighters, visitors as well as park developments and personal property of everyone concerned. Life and property on neighboring lands are also of concern. The paradox facing resource managers is that while fire is a threat, it is also an effective tool for reducing fire hazards.

Assessment Methodology
Assessment of environmental consequences on life and property is based on historically observed wildland fire intensity (the amount of energy released) and severity (impact on soils and amount of canopy burned) at Big Bend National Park or in similar vegetation communities elsewhere, and on the expertise of resource managers at the park. Staff also considered the number of wildland fires and escapes of several prescribed fires in determining fire safety.

Intensity of effects for life and property are defined as:

Negligible: The impact is at the lowest levels of detection with no injuries or property damage.

Minor: The impact is small, localized, and detectable. Mitigation would be a standard procedure and highly effective in minimizing risky activities such as thinning and prescribed burns to reduce fuels.

Moderate: The impact is readily apparent. Mitigation is moderately complex and effective activities such as rebuilding structures.

Major: The impact is severely adverse or exceptionally beneficial. Effects may be permanent. Mitigation may result in permanent positive change in human values or procedures, or mitigation to offset negative effects such as loss of historic register buildings may not be possible.

Short-term: Within the duration of a specific fire program activity such as a prescribed burn or suppression action.

Long-term: Beyond the duration of a specific fire program activity; perhaps longer than the tenure of the FMP.

Alternative A

Impact Analysis

Fire threats are greatest in late spring coinciding with peak visitation. Fire intensity is greatest where fuels have increased in the Chisos forests, along the riparian corridor and where exotic bunching grasses form dense understory mats. Alternative A (No Action) continues the direction of the 1995 RMP and 1994 FMP focusing on protection through suppression. Long-term direct beneficial effects accrue as developments continue to be protected by prescribed burns and manual thinning, mowing or herbicide applications. Strict decision criteria on natural ignitions mean that few natural fires are allowed to burn elsewhere in the park. Direct minor to moderate adverse effects accrue with the continual build up of fuels, particularly in the Chisos, that could threaten developments in the Chisos basin, hikers in wilderness, and some historic sites. A puzzle to staff is that despite buildup of fuels, few lightning fires have required suppression in the Chisos. This observation suggests that fire may not have burned as frequently as supposed or that fire is naturally contained by topography.

Under Alternative A the probability of high-severity fire in the Chisos increases when fuels are dry and wind speeds are high. Buildup of pine needles and leaf litter, ladder fuels, woody dead and down material, and closure of tree canopies will increasingly predispose the area to extreme fire conditions during summer fire season. Evacuating visitors from the Chisos basin and hikers from wilderness would be difficult during extreme fire events. Even with additional regional resources, the likelihood exists that the fire would burn large areas before containment. Creation of a one-mile suppression zone to buffer neighbors from fire has been successful where vegetation is sparse along west, north and eastern borders. It is more difficult along the riparian Rio Grande corridor where dense, flammable saltcedar and giantreed may hinder suppression efforts and endanger firefighters.

Mitigation actions are: Continuing to reduce fuels through prescribed burns and minimizing adminstrator’s reluctance to allow wildland fires; public education and notification of fire activities;

maintenance of cooperative agreements with neighboring landowner's and agencies; manual and mechanical fuel reduction; fuel breaks around developments; evacuation plans.

Cumulative Effects
Cumulative effects on life and property are expected to be minor to moderate with other activities having little impact on threats to life and property. Additional trails, built areas and growth of nearby communities reduce fuels and threat of fire. The relative isolation of the park minimizes the influence of the fire program on humans other than staff and visitors.

Conclusions
Alternative A may result in long-term minor to moderate adverse impacts to life and property by allowing fuels to increase. Burning of slash, mowing, herbicides and manual thinning and small prescribed burns pose minor short-term risks to life and property. Fuels continue to buildup in the Chisos, which raises the probability of more intense fires initiated by lightning strikes during the summer monsoon. Suppression of fire under extreme conditions in rugged terrain—a requirement under the current FMP—poses direct, moderate to major adverse risks to firefighters, hikers and visitors in the Chisos Basin. Fire occurrence and history of effects is limited but no impairment has occurred to date from fire.

Alternative B

Impact Analysis
Under Alternative B there will be more fire in the park. Initially this poses risks to life and property because of fuel accumulations in the Chisos, areas of flammable exotics, and increased need for fire fighting. Over the longer-term, increased experience by firefighters, familiarity with fire in different vegetation types within the park, and reduced fuels are expected to lower risks to life and property across the park. Allowing more fire is expected to reduce the risk of high-severity fire in the Chisos and the difficulties of evacuating people. Long-term beneficial effects to life and property are expected as neighbors learn and contribute to a more cohesive fire program.

Mitigation actions are: fuels assessment to allow natural fires to burn at low and moderate intensities; focus negotiations with neighbors on allowing fires to burn to natural boundaries; have adequately trained staff within the park or regionally available to handle the increase in fire activities.

Cumulative Effects
Increased wildland fire use may draw resources from other projects in the park over the short-term. Minor, long-term beneficial effects to life and property are expected as fuels are reduced across the park.

Conclusions
This alternative may expose firefighters to more fire and risk than other alternatives. While firefighters and the public may initially be exposed to greater risks; adverse impacts ranging from minor to moderate intensity over the short-term; these risks decline as fuels are reduced providing minor to moderate long-term benefits. Alternately, more exposure to fighting fire increases staff expertise leading to long-term moderate beneficial effects on life and property.

Alternative C

Impact Analysis
Impacts to life and property would be similar to those under Alternative B. More restrictive wildland fire use could necessitate more suppression activities that expose firefighters to dangers. Research burns would guide application of prescribed fire and wildland fire use over the tenure of the fire management plan, and program adjustment based on new knowledge should decrease risks to life and property.

Mitigation actions are similar to Alternative B. Research burns decrease potential adverse effects by providing a better understanding of fire effects.

Cumulative Effects
Cumulative effects are the same as Alternative B.

Conclusions
Effects are similar to B with increased risk to firefighters and the public in the short-term with increased burning. More frequent fires wildland fires and prescribed/research fires would reduce fuels, build firefighter skills, and a database that has the potential to provide long-term moderate to major beneficial effects on life and property. Conducting research burns would involve short-term minor to moderate direct adverse risks. Activities associated with research burns improve the skill base in the park and provide a platform for adaptive management, a long-term moderate to major beneficial effect in reducing risk to life and property.

Impact Topic (2): Preservation of Visitor Experience

Fire program activities may result in road closures and deter visitors; conversely some visitors are interested in fire and the post-fire activities offer interpretative opportunities.

Increased fires in the park would affect the approximately 300,000 annual visitors. Depending on the fire size, wind speed and direction, and fire duration visitors may be barred from roads, river, and mountains– the key recreational features of the park. Campgrounds may be closed and evacuations may be necessary from the Chisos wilderness and Basin. Smoke may veil the panoramic views of mountains and desert that draw many visitors. Interpretation of fire events is expected to lower aversion to the effects of fire on the landscape.

Communication by park staff via visitor centers, press releases, radio, signs and web site to visitors, local community and agencies of planned and unplanned fire activities is aimed first and foremost, at protecting life and property. Visitor Center staff are updated frequently to provide guidance on trail and road closures, safety and alternate destinations if needed. Backpackers are apprised of fire danger and responsibilities of using campfires and stoves before entering the Chisos when obtaining their camping permit. During periods of high fire danger, staff are posted at major trailheads to give further instructions. Evacuation plans are in place for the high country and Chisos Basin.

All alternatives have similar prescriptions governing prescribed fire and wildland fire use. Staff have perceived likely fire effects under these prescriptions and can plan, monitor and make cautious predictions based on these ranges. The planned reduction of fuels under the action alternatives will reduce threats to visitors from high-severity fire.

Assessment Methodology
Visitor surveys provide the background for understanding the park attributes most valued by visitors. Staff considered past experience with visitors during fire events and general knowledge of visitor patterns and expectations to determine impacts.

Intensity of effects for visitor experience is defined as:

Negligible: An action that could cause a change in visitor activities and/or aesthetic resource values, but the change would be so small that it would not be of any measurable or perceptible effect. Few visitors would be affected.

Minor: An action that would affect some visitors and cause a change in visitor's activities or aesthetic resources, but the change would be small and localized. Mitigation would not be necessary.

Moderate: An action that would cause a substantial measurable change in activities available to many park visitors. Mitigation to offset adverse effects would be necessary such as providing alternative routes and itineraries. Aesthetic resources would be degraded.

Major: An action would cause a severe change or exceptional benefit to the activities of most park visitors. The change would have substantial and possibly permanent effects on visitor use such as the loss of views and unique sites. Aesthetic resources would be substantially degraded. Mitigation to offset adverse effects would be needed.

Short-term: Duration of the fire event.

Long-term: Duration of the fire management program, or longer.

Alternative A

Impact Analysis
Prescribed burning to reduce fuels around developments generally occurs in fall and early spring outside peak visitation times. The intensity and duration would vary with fuel load and fire conditions within the prescription ranges. Visitors may experience short-term, minor direct effects when their plans are changed, views obscured, vegetation charred and wildlife disrupted from a prescribed burn. Disruption to visitors is minimized however, with a full suppression policy of lightning ignitions in areas most used by visitors. Views, wildlife, and access remains unimpeded to the river and the Chisos. These are direct, moderate to major benefits to visitors.

An indirect minor to major adverse impact of a suppression policy across much of the park is that visitors have become habituated to expect a fire-free and well-vegetated park. Tight decision criteria on ignitions and few fires in the park make it a challenge to familiarize visitors to the beneficial effects of fire for ecosystems. Under extreme conditions, high-severity fire may occur in the Chisos with long-term adverse effects on visitor experiences.

Mitigation actions are: inform visitors through multiple media, the visitor's center and entrance station; provide alternate destinations; link fire program activities to interpretation and education; time prescribed burns outside peak visitation periods; coordinate burns with adjacent and nearby land managers to minimize cumulative impacts to the region.

Cumulative Effects
Cumulative effects to visitors are most likely from continued increase in fuels. In the Chisos stresses from high stocking rates of trees are postulated as a reason for defoliation during drought. Increased dead material and continuing buildup of fuels makes high-severity fire more probable with long-term impacts on aesthetics in the park. Increased exotic species impacts wildlife patterns and exotic bunching grasses can lead to higher fire temperatures around rare and endangered cactus.

Conclusions
Current management strategies under Alternative A preserve visitor resources, amenities and aesthetic values, and have provided direct beneficial impacts for 60 years. Prescribed burns occur outside peak visitation times minimizing disruption to visitors and posing minor, indirect adverse impacts. Such fires also offer interpretive opportunities. Over the long-term continuance of Alternative A increases the probability of increasing fuels and risk of fire in woodlands and forest, and a widespread, high-severity

fire in the Chisos. Suppression of such a fire would create direct and indirect long-term adverse impacts to visitor resources and park aesthetics.

Alternative B

Impact Analysis
Greater wildland fire use and more prescribed burns would result in more periods of inconvenience. The duration and frequency of visitor use restrictions would decrease over time as fuel loads are reduced. Minor adverse effects can be expected from smoke and short-term localized trail and road closures. A possible effect of increased fire is reduced visitation from altered landscapes and limited access, or alternately, increased visitation as rubbernecks seek to witness landscape fires. Reduced visitation is an adverse impact to visitor's experience. Increase visitation draws park resources to providing greater interpretive experiences and providing more direction to visitors during actual fire events.

The long-term effect of more fire in the park is reducing the risk of high-severity fire in the Chisos and so preserving, aesthetics, plant communities and wildlife - direct beneficial long-term effects.

Mitigation actions are similar to Alternative A with increased emphasis of the benefits of fire in communications with the public.

Cumulative Effects
Cumulative effects are similar to Alternative A but more inconveniences are likely from increased wildland fire use.

Conclusions
More wildland fire would result in greater direct short-term minor to moderate adverse impacts to visitors as they experience road closures, smoke and limited access to the park. Reduction of fuels particularly in the Chisos minimizes the threat of high-severity fire maintaining a resource valued by visitors and limiting the need for disruptive suppression tactics that could include overflights. Greater interpretive efforts by park staff would provide long-term indirect beneficial effects as visitors support policies that encourage natural fire regimes in park ecosystems.

Alternative C

Impact Analysis
Under Alternative C prescribed burns and natural ignitions follow a similar pattern to Alternative B. Visitors will suffer short-term, direct, adverse impacts from smoke and closure of roads and trails denying access to views, wildlife and amenities. Research burns may also cause short-term adverse effects to visitors. Scientific assessment of these burns is also expected to yield indirect beneficial effects over the long-term from improved management of cherished resources and habitats. Under Alternative C the potential for high-intensity widespread wildfires in the Chisos continues and will not abate until staff understand how to safely reintroduce fire into areas of high fuels.

Mitigation actions are the same as Alternative B.

Cumulative effects
Cumulative effects are similar to Alternative B with benefits from fire taking longer to accrue.

Conclusions
Effects of Alternative C are beneficial and minor over the short-term. Scientific evaluation of research burns applied to fire policy and interpreted for the public, provide a touchstone enabling visitors to weigh

immediate direct adverse effects with potential long-term beneficial effects on ecosystems. Benefits to visitors are expected to be greatest under this alternative.

Impact Topic (3). Local Economy

Fire events provide business for local merchants and firefighters but may deter visitors. More routine fire events provide extended benefits to the local economy than a single large high-severity fire.

The park lies in a sparsely populated region in connection with other large protected landscapes. Big Bend is a major employer of this region and supplies high-quality permanent employment, seasonal jobs and volunteer opportunities in a number of departments. Local gateway communities provide motel and supplies to park visitors and employees, furnish seasonal firefighters such as Los Diablos for the fire program, and provide support services for the luxurious Lajitas resort. Benefits to the local economy depend upon the size, intensity and duration of fires. A large, high-intensity fire may provide a one-time windfall for local merchants while more routine fire events are likely to provide more lasting impacts to suppliers and seasonal employees.

Assessment Methodology

Long-time park staff provided information on the types of expenditures associated with fires and their relative benefit to the local economy. For example, revenues for merchants increase when firefighters cash their paychecks to buy food, water and other supplies during fire events.

Intensity of effects for the local economy is defined as:

Negligible:	Economic and socioeconomic effects would not be affected or the effects would not be measurable.
Minor:	The effects on economic and socioeconomic conditions would be small but measurable, affecting a small portion of the local population.
Moderate:	The effects on economic and socioeconomic conditions would be apparent in the vicinity of the park.
Major:	The effects on economic and socioeconomic conditions would be readily apparent and would substantially change the economic or social services within the area.
Short-term:	For a specific fire program activity.
Long-term:	Beyond the duration of a specific fire program activity such as a fire season or the duration of the FMP.

Alternative A

Impact Analysis

Under Alternative A, a policy of prescribed burns around developments and suppression elsewhere in the park has resulted in a few fires of short duration with little impacts on visitors or the local economy. Continual buildup of fuels in the Chisos increases the problem of widespread, high-intensity fire under extreme conditions. A large fire would create short-term direct moderate benefits for retail merchants. Visiting and local seasonal firefighters may also cash paychecks and purchase items in the areas returning revenues to local businesses. Overall effects on the economy are sporadic under this alternative.

Mitigative actions are: continue to employ local firefighters including Los Diablos on a seasonal basis whenever possible; provide options for local merchants to supply goods and services for the fire program when practical; keep local communities and neighbors notified of park activities to minimize adverse effects.

Cumulative Effects
Cumulative effects outlined at the beginning of the chapter are likely to increase revenues to the local economy independent of fire activities. These effects include the impacts of building trails, constructing housing, a fire office and visitor center at Panther Junction, and increasing visitation as gateway communities grow. Trails provide greater accessibility to more of the park and together with improved visitor amenities are likely to draw more visitors resulting in direct short to long-term beneficial effects on the local economy. Visitors spend money on meals and souvenirs while staying at the park and nearby motels.

Conclusion
Alternative A would result in short-term moderately beneficial impacts from seasonal firefighter employment and high visitor use- the results of a primarily suppression fire policy. Should a high-severity fire occur during extreme weather conditions local merchants and visiting firefighter would receive a one-time windfall. Post-fire economic effects following such a fire are unknown. Visitors may choose to investigate post-fire effects thereby boosting local revenues, or choose another, greener destination. There is sufficient staff within the park to manage the fire program with minimal outside additional support.

Alternative B

Impact Analysis
Alternative B represents a shift from primarily suppression activities under Alternative A to much more fire from lightning ignitions. Additional fires may tax existing staff to meet safety requirements necessitating reallocation of staff duties and/or hiring additional seasonal firefighters to meet high demand periods. Under this scenario, Alternative B would result in direct, short-to long-term beneficial effects to seasonal workers and local merchants. More fire may dissuade visitation (with negative effects on the economy) or encourage visitation (with positive effects on the economy) depending on visitors' perceptions.

Mitigation actions are: similar to Alternative A with greater emphasis on education and interpretation to counter any falling visitor attendance such as Visitor Center information on alternate destinations, closures or cautions; hire additional staff locally if possible.

Cumulative Effects
More fire is allowed in the park under Alternative B potentially straining existing resources during fire season. Other fires on nearby state lands, private holdings and the Mexican preserves may further strain park resources. Regionally more routine fire events would benefit local suppliers of goods and services and provide a pool of expertise, which could serve a number of agencies. These effects would cumulatively result in minor to moderate direct beneficial impacts to local seasonal employees and merchants, with benefits diminishing as fuels are reduced over time.

Conclusion
Alternative B would result in short to long-term beneficial effects by providing income to seasonal firefighters and sales to local merchants as fire frequency increases in the park. Benefits are expected outside fire season for prescribed burns and during fire season for natural ignitions, extending the period of benefits to firefighters and merchants.

Alternative C

Impact Analysis
Alternative C is similar to Alternative B but with more planned prescriptive/research fire events. Conceivably this alternative could provide the most reliable economic benefits to seasonal employees and merchants. The additional tasks and seasonal employment to undertake monitoring and control of more fire events would be expected to provide short- to long-term direct beneficial effects to firefighters and suppliers.

Mitigation actions are the same as for Alternative B.

Cumulative Effects
Cumulative effects would taxed already burdened permanent staff. The economic effects of stress are unknown in this scenario. The benefits to seasonal employees, and merchants are likely to be direct, beneficial and minor to moderate over the life of the FMP.

Conclusion
Under Alternative C beneficial impacts to the economy would range from minor to moderate depending on fire frequency, duration, intensity and size, and whether permanent park staff can meet staffing and additional seasonal firefighter needs.

Impact Topic (4): Vegetation

While trained observers pointed to the need for reintroducing fire into Big Bend since the 1940s (McDougal) and 1960s (Leopold), park staff followed the national policy of suppression. Historical vegetation structure has changed from heavy grazing prior to park formation. Extended drought slowed recovery of grasses on limestone allowing woody species to increase (Muldavin et al. 2001). High elevation grasslands appear to have recovered however, but woodland canopy is far greater than that recorded by biological surveyor Vernon Bailey in 1901 (Schmidley 2002). The park began a modest prescribed burn program in 1980s to protect developments. Fuels have continued to increase across the park and in preparing this EA, staff recalibrated vegetation types to reflect fire program concerns. Staff added measures to protect unique habitats, took account of the effects of spreading nonnative plants, and developed a research agenda to better understand ecological processes.

<u>Floodplain and Upland Riparian</u>
Fire effects on species: Table A-1 in Appendix B
Until the formation of the park and frequent visitors, fire was uncommon along the river. Spring floods removed understory, which could act as ladder fuels, from the scattered gallery forests of cottonwood and mesquite. Relative humidity and fuel moisture were high keeping fires small. Frequent human visitation, together with lower river flows and dense stands of saltcedar and giantreed has led to an increase in fires along the river. Saltcedars ability to reestablish rapidly from seed, roots and stem means it will continue to outcompete native species. Bermuda grass and buffelgrass, both exotics are also established along the riparian corridor and form mats of fuel under moist summer growing conditions. Both respond rapidly after fire and can outcompete local natives. Fire is an impediment in this category unless followed up with control measures for saltcedar and the exotic grasses.

Upland springs have had saltcedar removed. The IDT proposes to protect native canopy species from fire if possible, and remove exotics as they appear.

Scrub Desert

Fire effects on species: Table A-2 in Appendix B

Desert scrub is dominated by shrubs (creosote, mariola and ocotillo), and succulents (prickly pear, lechuguilla, and Texas hetchia or falseagave). These shrubs will carry fire under high winds. Grasses are subdominent and provide insufficient fuels to carry fire. Muldavin et al. (2001) in a survey of 77 transects from 1950 to 1996 in the northwest of the park identified soil type, elevation and moisture conditions as determining shrub cover. Greater runoff and erosion and high evaporation during the growing period leads to establishment of deeper-rooted and probably widely-spaced shrubs on drier limestone soils. Recovery of grasses is not expected except during cycles of above average rainfall. Wonzell et al. (1996) show a similar correlation between shrub and grass cover and predominant landforms. Almost half the park is scrub desert, which does burn when canopies are dense, winds high, and plants close enough for fire to carry. Depending on biomass production, fire may occur every 30-250 years (infrequent) (USFS – FEIS site). Staff are establishing research plots to understand if fire can increase tobosagrass and chino grama.

High Desert Grasslands

Fire effects on species: Table A-3 in Appendix B

The largest fires in the park have occurred in this vegetation type (>1,000 acres). The studies above would have predicted post-grazing recovery on igneous, depositional ecotone with low runoff and evaporation during the growing season. Shrubs are still present in these grasslands and fire would shift them towards occupying shallow rocky soils on ridge tops and along drainage bottoms. The IDT know that lightning caused fire is likely to spread uphill into woodlands along drainage bottoms. Control will be extremely difficult because of the high fuel loads under some woodlands and forest. Fire return intervals for desert grasslands may be as frequent as 7-10 years (McPherson 1995). Sexton and Kaufmann estimated up to 20 years for this association (Burns will favor an increase in grasses and containment of shrubs and seedling trees.

Shrub Woodlands

Fire effects on species: Table A-4 in Appendix B

Oaks, acacia, mimosa and sumac all resprout after fire and the small shiny-leaved shrubs reflect fire. The grazing era removed grassy understory, and dense clumps of aloysia persist in former stock corrals. Fire would have thinned shrub densities and killed sapling juniper and pinyon. Because of grazing and suppression there is perhaps more shrub cover than before Europeans, skewing types of habitat (black-capped vireo) and foods available (berries eaten by black bear). Alligator juniper sprouts vigerously from the underground base and the bark protects mature trees from damage. Redberry juniper may reach maturity within 10 years. Prescribed fires at low to moderate intensity are unlikely to be useful in removing current mature junipers but high-intensity fire may remove junipers for up to 50 years. Mexican pinyon is relatively resistant to fire. Moir (1982) counted four fires in a tree ring sample in an 80-year-old tree. Fire return intervals for maintaining open stands of pinyon-juniper are commonly 10-30 years (FEIS web site). Baker and Shinneman (2004) point to the difficulty of lowering P-J densities using low-intensity fire (usually becomes high-intensity) and recommends experimental work on site to determine correct prescriptions.

Grassy Woodlands

Fire effects on species: Table A-5 in Appendix B

This predominately pinyon-juniper-oak vegetation is a fire maintained assemblage. Trees are mature and unlikely to be seriously impacted by low-intensity fire. However, fuel levels are moderate to high and canopies are closing or closed which together could lead to crown fire. More fire will open canopies and increase grasses but a cycle of burn will probably be necessary to achieve the greater grass cover recorded by Vernon Bailey in 1901.

Forest
Fire effects on species: Table A-6 in Appendix B
Moir (1982) found 10 fires between 1770 and 1940 at a range of 9-60 years and estimated fire frequency in this assemblage at 70 years (Moir 1982). Baisan and Swetnam (1995) in averaging results across 63 sites suggested 25 years. The numerous species with differing responses to fire suggest that topography has shaped fire behavior. Redberry juniper can tolerate fires 10-20 years, Pinchot juniper every 30-50 years, and Alligator Juniper 20-30 years. Aspen typically regrows as a clone after a severe fire event. Arizona Cypress is quite intolerant of fire and probably survived due to patchy fire. Oaks typically resprout after fire from the base. Mature ponderosa pine is expected to survive fire. The talus slopes, sheer cliffs and rocky terrain would direct fire so that mosaics of burned and unburned vegetation occur.

The IDT want to retain most mature trees and burn understory fuels and saplings at low intensities.

Assessment Methodology
Impacts of the fire program on vegetation were developed from the experience of park staff, the US Forest Service maintained fire effects web site, and from the literature.

Intensity of effects are defined for vegetation as:

Negligible: An action that could affect individuals with no measurable effect on populations or vegetative communities. Impacts would be barely perceptible to landscape features

Minor: An action that could cause a change to populations, but the change would be small, and if measurable, would have a small and localized effect and not cause decrease or increase of species diversity in the park. Impacts would remain localized and confined to a single element of significant characteristic of a landscape such as a particular plant community over a small area. Restoration would be relatively easy.

Moderate: An action that could cause a change to populations and communities that increase or decreases species diversity in the park. The change would be localized and not considered a threat to the long-term survivability of the species in question. Impacts would be sufficient to cause a noticeable but not substantial change in landscape features such as alteration of a particular plant community in several localized areas. Restoration may be time-consuming, costly, or relatively complex.

Major: An action that could decrease the species diversity of the park, be considered a threat to the long-term survivability of populations in question and/or eliminate the population of a species that is locally endemic or considered key to the natural integrity of the park. Impacts would result in substantial and highly noticeable changes in landscape features, such as complete loss of vegetation over a widespread area. Restoration may not be feasible.

Impairment: A major, adverse impact to a resource or value whose conservation is (1) necessary to fulfill specific purpose identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Short-term: A return to the pre-event range of variability in distribution and abundance of species or arrangement of vegetation on the landscape within the natural fire interval of the affected habitat.

Long-term: Unlikely to return to pre-event range of variability in distribution and abundance of species or arrangement of vegetation on the landscape within the natural fire interval of the affected habitat.

Alternative A

Impact Analysis
Alternative A would continue suppression of most natural ignitions across the park. This would protect unique habitats such as upland springs and dunes, and the floodplain where exotic plant establishment and seed dispersal may be enhanced by fire, favoring more fire tolerant vegetation over time. Excluding fire from mountain meadows, woodlands, and grasslands allows further shrub encroachment and canopy closure, which impacts vegetation structure and species diversity— long-term adverse impacts. The dynamics of fire in these altered environments may be difficult to predict. Fuel buildup in the woodlands and high fuel loads in Chisos forests increase the risk of high-severity, widespread fire to relic and rare systems under extreme conditions during the summer fire season. Wilderness suppression requirements increase the difficulty of controlling fire and create hazards for firefighters and the public. Landscapes and ecological processes may be changed for many decades. Under this alternative effects are likely to be moderate to major, direct, indirect, adverse and long-term.

Prescribed fire with mechanical and manual fuel reduction around developments would result in mortality to a small number of plants. Localized, direct minor effects to plant communities would result from the activities of work crews, such as: laying firelines, burning slash piles, and removing individual trees and shrubs. Burning would release some nutrients to the soil and allow seedling establishment.

Mitigation actions include: locating potential firebreaks, staging camps and spike camps ahead of fire; restore site immediately after fire if needed; restrict prescribed fire to low and moderate intensity; use Minimum Impact Suppression Techniques whenever possible; manage wilderness in accordance with the Wilderness Act including: hand tools rather than mechanized tools and aircraft; no spike camps, crews or other personnel overnight; biodegradable retardant if it must be use; avoid spills, foam or erosion near water.

Cumulative Effects
Cumulative actions which add to proposed actions under the fire program include:

- Large fires on lands adjacent to the park at the same time as fires within the park may create problems for obtaining sufficient resources to manage fire and probably result in continued suppression – an direct, minor to moderate adverse impact.
- Fire events at Big Bend preceding and following the term of the new FMP. High-severity fire may occur leading to loss of mature trees and views.
- Continued fuel accumulations in the Chisos predispose the forests and woodlands to high-severity fire – a moderate adverse direct impact.
- Expansion of nonnative plant species increases the flammability of these sites jeopardizing endangered species and changing fire regimes.
- Pilot revegetation of natives along the riparian corridor will remove saltcedar, a minor to moderate beneficial effect.
- Past and future flood and erosion events would reduce seedling in low desert areas (erosion) but high rainfall may increase recruitment of seedlings elsewhere – minor long-term beneficial effects.
- Defoliation of trees by caterpillers in the Chisos during periods of stress is an adverse effect creating more fuels. Prescribed burns that remove fuels provides minor to moderate beneficial effects to mature trees.

- Expanded interpretive and education programs may lead to minor beneficial effects as the public develop understanding of fire's role in the landscape.

Conclusion
Actions under Alternative A limiting the spread of exotic species and preventing the loss of valued habitats through suppression provides beneficial direct short-term impacts. Restrictive initial decision criteria that determine whether fires are allowed to burn have curtailed the use of natural ignitions allowing fuels to build up and preventing fire in fire-adapted systems. High severity fire in the Chisos leads to moderate to major adverse impacts over the short-term. Long-term the effects are unknown.

Under Alternative A, there would be no impairment of the park's vegetation because there would be no major adverse impacts to resources whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Alternative B

Impact Analysis
The goal of Alternative B is to atempt to quickly reduce fuels across the park and avert a high severity event. Decision criteria on ignitions are flexible and prescriptions maintain safety by only allowing fires to burn at low to moderate intensities. Under this alternative, there is confidence that burning even if the fire frequency and effects of fire are unknown will benefit park ecosystems in the long-term. Fuels would be reduced, plant communities regenerated, and a natural fire regime returned to the park. More frequent disturbance, however, could predispose sites to invasion by exotic species changing flammability and species composition over time. More fire tolerant saltcedar is displacing cottonwood and willow along the riparian corridor. Buffelgrass, Bermuda grass and giantreed predispose the floodplain to more and hotter fires. Without control of exotic species following fire there would be long-term direct minor to moderate adverse effects as vegetation composition shifts to more fire tolerant species. More frequent fire could maintain high desert grasslands by increasing species diversity, reverse shrub encroachment in meadows, remove saplings and water competition among oak, pinyon-juniper woodlands, remove ladder fuels and duff in forests, and through creation of low fuel buffer areas provide greater protection for legally protected species and cultural resources. These impacts are expected to be direct moderately beneficial and long-term.

Prescribed fire with mechanical and manual fuel reduction around developments would result in mortality to a small number of plants. Localized, direct minor effects to plant communities would result from the activities of work crews, such as: laying firelines, burning slash piles, and removing individual trees and shrubs. Burning would release some nutrients to the soil and allow seedling establishment.

Mitigation actions in addition to those under Alternative A include: flexible boundary agreements with neighbors would allow fire to be controlled at natural barriers reducing the effects of control and suppression activities on vegetation.

Cumulative Effects
Similar to Alternative A; agreements with neighbors may lead to minor short-term, direct beneficial effects for vegetation.

Conclusion
Minor adverse short-term impacts from fire with moderately long-term beneficial effects to vegetation communities and fuel levels as natural fire regimes are restored. Applying mitigation measures to burned areas of exotics provides short-term beneficial effects.

Under Alternative B, there would be no impairment of the park's vegetation because there would be no major adverse impacts to resources whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Alternative C

Impact Analysis
Under Alternative C prescribed fires and mechanical and manual fuel reduction around developments would result in mortality to a small number of plants as for the other alternatives. Like Alternative B, more natural and prescribed fire would be allowed in the rest of the park with similar effects to fire-tolerant habitats and areas of exotics. Alternative C adds research burns to identify fire-effects to Chisos forests and woodlands, to better understand restoration of grasslands, enhance habitat of threatened species where possible, assist in the protection of cultural resources, and aid restoration of riparian areas. Observing fire dynamics under low and moderate intensity burns coupled with careful pre-fire and post-fire monitoring would aid reintroduction of fire where the fire regime is not well documented. Using research burns is expected to lower any unknown but potentially adverse effects from allowing prescribed and natural ignitions where suppression has been the norm or where fire frequency is unknown. Fire would be gradually reintroduced with the effects leading to direct beneficial, long-term benefits to vegetation. An adverse indirect effect is the time required until effects are understood and applied. A high-severity, widespread fire could occur in the Chisos before research is completed and implemented into fire operations.

Mitigation actions are the same as Alternative B.

Cumulative Effects
Cumulative effects are the same as Alternative B.

Conclusion
Short-term adverse minor to moderate impacts are expected from vegetation loss with direct long-term beneficial effects to plant communities.

Under Alternative C, there would be no impairment of the park's vegetation because there would be no major adverse impacts to resources whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Impact Topic (5): Threatened & Endangered Species
Protecting federally listed species require careful precautions to safeguard individuals, populations, and their habitats over the long-term.

Wildlife
The park supports many animal species, but staff considered only those that for reasons of population size, federal protection, or limited habitat, needed special consideration in this EA. Potential fire effects

were initially investigated for 11 federally protected animals listed in Table III-1 and sensitive species listed under this topic in Chapter III. The endangered Mexican long-nosed bat (*Leptonycteris nivalis*), and endangered black-capped vireo (*Vireo atricapilla)* were formally evaluated for potential effects under the three fire alternatives. The effects of the FMP on these two species is being evaluated under a Biological Assessment (BA).

Fire is known to cause direct injury and death to animals caught in its path (Howard, Fenner and Childs 1959). Effects depend on the size, intensity, and speed of fire, and the speed and mobility of the animal. Mountain lion, deer, and bear without young could be expected to flee an advancing fire front but small animals may be unable to escape. Snakes, lizards, rodents and amphibians living underground can survive intense fire insulated by earth (Lyons et al. 2000). The Texas horned lizard survives wind driven fire in desert scrub because carrier fuels are discontinuous providing avenues for escape. Birds and bats are highly mobile and unlikely to be adversely affected by fire directly if it occurs outside nesting or roosting seasons (Robbins and Myers 1992). While fire may kill some individuals, in general effects on populations are usually negligible (Patton 1992). The Chisos is likely to pose greatest direct effects to small populations of bear and mountain lion with young, and nesting birds during extreme fire conditions.

Indirect effects of fire on habitat have greater effect on populations then individuals (Singer et al. 1989) Effects include migration, predation, starvation or death due to loss of habitat. Fire may kill agaves needed by nectar feeding bats, destroy nesting and fledgling sites for birds, eliminate insect habitat, and expose adults and young to weather extremes. Under the preferred alternative patchy burns during cool seasons outside nesting periods ensures mosaics of unburned habitat remain, reducing browsing pressure and providing alternative cover and food for small mammals, retiles and birds. Limited food sources following fire may lead to starvation of female bears and migration of males. Raptors however, may be attracted to recently burned areas that expose rodents and other prey. Successional changes from woodland or forest to shrublands or from shrublands to more grasslands will influence wildlife distributions.

Increased sediment loads may occur from erosion following fire. Amphibians and the Texas hornshell could be adversely affected as silt fills seeps and drainages, but agricultural pesticides in low river flows may prove a bigger threat. Fish are affected by changes in physical and chemical qualities of water following fire. Sediment loads increase because of erosion and may kill eggs or fry (Patton 1992). Removal of vegetation along waterways by fire may increase water temperatures leading to changes in species composition and distribution. In general these indirect effects are more important because slow reestablishment delays or may jeopardize recovery of populations.

Plants

Staff evaluated 33 plants for potential effects under the FMP and one species the Chisos Mountain hedgehog cacus is being formally evaluated in a BA by the USFWS.

Plants survive fire by either surviving the direct effects of fire, or surviving post-fire conditions (Whelan 1995). Survival during fire is facilitated by thick bark, suppression of understory limiting ladder fuels, and non-flammable foliage. Root callus, deep underground roots, soil seed reserves, epicormic buds, regeneration of vegetative plant parts, post-fire weather, and triggering of seed capsules by fire or smoke, facilitate regeneration following fire. Staff are most interested in maintaining species diversity, expecting populations of any particular species to be dynamic over time. The fire program is an investigative tool to understand how this may be achieved.

Methodology

Information from the U.S. Fish and Wildlife Service (USFWS) species recovery plans, park monitoring reports, and the experience of researchers and park staff were consulted in understanding how the FMP may affect threatened and endangered species.

Intensity of effects for threatened and endangered species is defined as:

Negligible:	No federally listed species would be affected or the alternative would affect an individual of a listed species or its critical habitat, but the change would be so small that it would not be of any measurable or perceptible consequence to the protected individual or its population.
Minor:	An individual(s) of a listed species or its critical habitat may be affected, but the change would be small and would not adversely affect the continued existence of the species or cause the death of any individual of the species.
Moderate:	An individual or population of a listed species, or its critical habitat would be noticeably affected. The effect would have some long-term consequence to the individual, population, or habitat and would be difficult to mitigate.
Major:	An individual or population of a listed species, or its critical habitat, would be noticeably affected with long-term, vital consequences to the individual, population, or habitat.
Impairment:	A major, adverse impact to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.
Short-term:	Recovers in less than one to three years after the fire or other action (depending on the species).
Long-term:	Takes more than one to three years to recover after the fire or other action (depending on the species).

The Biological Assessment prepared in support of the FMP revision applies USFWS criteria:

No Effect. When a proposed action would not affect a listed species or designated critical habitat.

May affect/not likely to adversely affect: Effects on special status species or designated critical habitat are discountable (i.e. extremely unlikely to occur and not able to be meaningfully measured, detected, or evaluated) or completely beneficial.

May affect/likely to adversely affect: When an adverse effect to a listed species or designated critical habitat may occur as a direct or indirect result of proposed actions and the effect is either not discountable or completely beneficial. Staff of the USFWS review the park's assessment of impacts on threatened and endangered species and in response issues a Biological Opinion identifying agreement or areas requiring modification.

Is likely to jeopardize proposed species/adversely modify proposed critical habitat: The appropriate conclusion when the National Park Service or the U.S. Fish and Wildlife Service identifies situations in which the fire program could jeopardize the continued existence of a proposed species or adversely modify critical habitat to a species within or outside park boundaries. Staff of the USFWS review the park's assessment of impacts on threatened and endangered species and in response issues a Biological Opinion identifying agreement or areas requiring modification.

Alternative A (No Action)

Impact Analysis

Mexican long-nosed bat (*Leptonycteris nivalis*)
Under Alternative A most fires are suppressed protecting the roost and foraging range of the bat but fuels are allowed to buildup across the park and ecosystem processes are interrupted.

Mitigation actions include: assessment of agave populations (the main food of the bat) to ensure 80% of foraging area is present at any time including after fire, maintenance or suppression actions; suppression of all high-intensity fires in the vicinity of foraging areas; careful fuel reduction near the roost entrance; retaining a buffer zone of low fuels around the roost site; no retardant drops where the roost could be impacted; identification of potential fireline and spike camps prior to fires; construction of firelines using minimal impact techniques; and rehabilitation of areas near the roosting site by replanting; handbrushing lines; and, removing trash and preventing erosion. Post-fire monitoring would assess fire effects and plant recovery.

Black-capped vireo (*Vireo atricapillaus*)
Under Alternative A fires have been suppressed, protecting the birds' territories and nesting sites. Vireo habitat may be an artifact of suppression, the shrub understory growing in response to removal of grasses throiugh grazing. No fire in over 100 years makes these canyon drainages very vulnerable to fire from increased fuels.

Mitigation actions include: not burning any areas currently occupied by vireos; assessing current habitat by vireo experts to understand likely responses from fire; identifying where fuel reduction would be beneficial to habitat; identifying other areas in the park with similar vegetation structure that could be occupied; maintaining a ¼ mile buffer from fire; identifying potential firelines and staging camps ahead of fire; following fires with restoration actions such as replanting and brushing handlines and preventing erosion; and, seeking funding for a population dynamics study to understand why vireos are not occupying suitable habitat. Any research fires in nearby areas would be conducted in late fall and winter outside the vireo nesting season.

Chisos Mountain Hedgehog Cactus (*Echinocereus chisoensis* var. *chisoensis*)
This cactus is found primarily on gravelly limestone derived terraces and sloping pediments with sparse associated vegetation of lechuguilla, creosote and dog cholla. Strict decision criteria on ignitions together with few fuels in the cactus habitat have protected current populations from fire.

Mitigation actions include: establishing new populations from plants and seed, removing buffelgrass around populations and individuals, assigning a resource advisor preferably the park botanist to any fire in the area, identifying firelines and staging camps ahead of fires, avoiding retardant drops in the vicinity of the plants, and rehabilitating areas following fire suppression actions such as recontouring soils, repositioning rocks, or restoring drainage lines.

Guadalupe Fescue (*Festuca ligulata*)
Currently the only known populations of this grass are in the Chisos Mountains of Big Bend National Park and the Sierra del Carmen in Mexico. A small population of about 500 plants occurs on shaded moist slopes in Boot Canyon, and is managed under a Candidate Conservation Agreement with the Austin Texas Ecological Services of USFWS signed by the park on 9 April 1998. It is not known whether fire would potentially benefit this species. Park botanist Joe Sirotnak is currently evaluating the plants' lifecycle and requirements for reproduction. Seed set is prolific but establishment is extremely low perhaps due to high duff levels. Fire is one research approach being considered for very small areas to

test seedling establishment in mineral soils. A determination is not made for candidate species. The park will continue to coordinate with the USFWS before burns take place that may affect this species.

Under Alternative A, duff levels will continue to increase and possibly interfere with seedling establishment.

Southwestern Willow Flycatcher (*Empidonax trailii extimus*)
Southwestern willow flycatcher prefers thick streamside vegetation, and its rarity is a consequence of the loss of such habitat in the Southwest. In addition to habitat destruction by humans, cowbird parasitism, predation, and negative effects of recreation and research activities are all cited as threats (New Mexico Game and Fish Department 2000) leading to federal listing as endangered on September 1992 (57 FR 39664). Information on flycatcher use of the lower Rio Grande is anecdotal. The flycatcher has been recorded as nesting in the middle and lower stretches of the Rio Grande River in saltcedar (Mark Sogge, personal communication, March 2004). Since 1990, Kelly Bryant working on state lands throughout the southwest has observed the flycatchers during migration in the lower Rio Grande but has not found evidence of them nesting along the river (Personal communication, March 2004). Mark Flippo, park biologist at Big Bend confirmed Bryant's observations (March 2004). If the flycatcher nests in the riparian corridor it would be present from mid-May through September.

Fire may be a component of pilot programs in 2006 testing methods to restore sections of native riparian vegetation along the 118 miles of Rio Grande inside the park border (Joe Sirotnak, personal communication, January 2004). These small sections would be surveyed prior to any disturbance in the area. The susceptibility of the flycatcher to fire effects is slight given the bird's rarity in this region, and the extensive areas of riparian vegetation in the park, and the commitment to suppression along park borders. Because of the rarity of flycatcher sightings, a "may affect- not likely to adversely affect" determination is made for this species.

Alternative A ensures suppression of fires along the riparian border with Mexico but suppression efforts may damage vegetation.

Northern Aplomado Falcon (*Falco femoralis septentrionalis*)
This medium-sized falcon was once found throughout southeast Arizona, southern New Mexico, West Texas and much of Mexico. Generally they inhabit open grasslands with scattered trees and relatively low ground cover, needing a supply of suitable nesting platforms and an abundance of small to medium-sized birds as prey. The park's grasslands have probably changed dramatically since the 1880s and what may have been ideal habitat has been greatly diminished. Aplomados have been reestablished at Marfa, 100 miles northwest of the park but none have been sighted in the park. The preferred alternative may improve habitat conditions for Aplomados and attract them to the park in the future. The determination for this species is "no effect."

Under Alternative A, suppression allows continued shrub encroachment into grasslands dissuading return of this species.

Big Bend Gambusia (*Gambusia gaigei*)
The greatest dangers to fish numbers come from competition with Western mosquitofish and the introduced Green Sunfish, which probably arrived through dumping of excess bait into the ponds. Fire program threats include petroleum from vehicles leaking into the ponds and changes in pH from fire ash. A prescribed burn close to the ponds in February 2003 dumped high levels of ash without ill-effect to the fish suggesting that the change in pH was either not large or not of sufficient duration to cause harm (Raymond Skiles, Personal communication, February, 2004). A nearby bridge made from recycled plastic may pose problems if it burns and smoldering residues drop into the water. The ponds have been protected from runoff and petroleum leaks by large earthen berms. Future prescribed burns would protect

mature cottonwoods and remove some vegetation reducing the intensity of the burn. Burns would create a mosaic to ensure some shading and protection from predators. Research burns that reduce fuels may improve spring flows increasing volume and improving water quality. A “may affect-is not likely to adversely affect” determination is made for this species under the proposed fire alternative.

Without fuel reduction measures there is the risk of fire around the ponds particularly as they are near a well-used camping area. Suppression under Alternative A would continue to increase fuels leading to higher risk prescribed burns.

<u>Bunched Cory Cactus</u> (*Coryphantha ramillosa*)
This cactus occurs on the limestone of the Boquillas and Santa Elena formations with creosote and lechuguilla. The plant is also found in Terrell County, Texas and the state of Choahuila in Mexico. Park staff are currently mapping all known locations of this species and will continue to update GIS databases of rare, endemic, and listed plants (Alex, 2003). Researchers Kathy Rice, Ted Anderson and Robert Schmalze at the Desert Botanical Gardens in Phoenix have been analyzing the reproductive characteristics, microhabitat, and associated vegetation of this cactus (1 April, 2004). The proposed alternative for the FMP is unlikely to cause adverse impacts on known populations in the absence of grasses and other vegetation to carry fire. The determination for this species under the preferred alternative is “may affect – not likely to adversely affect.”

While suppression under Alternative A protects current populations, the suppression activities may inadvertently damage plants.

<u>Lloyd’s Mariposa Cactus</u> (*Sclerocactus mariposensis*)
Named for the Mariposa Mine in Southern Brewster County where it was first discovered, this cactus occurs on rocky, gravelly soils primarily derived from limestone. It is an attractive, rounded plant to four inches with pale star-shaped spines and pink, green or tan flowers in February through March, with fruiting from April through May. This cactus was listed as threatened in 1979 because of over-collecting. A recovery plan was developed in 1992 by the U.S.FWS. Park staff estimate there are many hundreds of individuals on about 30 sites primarily in the Eastern side of the park and the Black Gap Wildlife Management Area at elevations of 2,600-4,600 feet. Associated vegetation includes sparse creosote, lechuguilla, candelilla, leather stem, and other cacti. It is unlikely that fire will have an adverse impact on the park populations as fuels are sparse and discontinuous. Therefore the park makes a determination of “may affect- not likely to adversely affect” for the proposed fire program.

While suppression under Alternative A protects current populations, the suppression activities may inadvertently damage plants.

<u>Hinckley’s Oak</u> (*Quercus hinkleyii*)
This oak is unlikely to occur in the park as the extremely distinctive foliage is difficult to miss.

Mitigative actions are: following USFWS Recovery Plans for listed species; ensuring resource experts are consulted during fire operations; preemptive plans are in place before fires to minimize damage; non-fire fuel reduction or prescribed burns are used to protect habitat; post-fire monitoring is used to improve prescriptions.

Cumulative Effects
Cumulative effects include

- Development of walking trails in the Chisos and along the river may increase disruption to established wildlife use patterns – a minor adverse effect.
- Large fires on state and private lands adjacent to the park may jeopardize recolonization of animals (e.g. bear) and plants if the park has losses after fire.

- High-severity fire could occur before the outcomes of the preferred alternative take effect – a minor to moderate direct adverse effect.
- Continued fuel accumulations in the Chisos increase the likelihood of high-severity fire and the loss of rare plants and animal habitat – direct, adverse minor to moderate effects.
- Expansion of nonnative plant species increases the intensity of fire – a direct adverse minor effect.
- Pilot revegetation of natives along riparian corridor could be minor direct beneficial effect.
- The effect of past and future flood and erosion events are difficult to ascertain.
- Defoliation of trees by caterpillers in the Chisos during periods of stress increases woody fuels and fires burn hotter – a minor to moderate direct adverse effect.
- Expanded interpretive and education programs may increase public support for fire operations that reduce fuel loads and protect habitat - a minor to moderate direct beneficial effect.

Conclusion
In the short-term, effects to listed plant and animal species are minimized by suppression. The likelihood of adverse affects increases with time as fuels build and fires are likely to be more widespread and burn hotter. Removal of habitat is likely to cause greater loss than direct impacts of fire to animal species.

Under Alternative A, there would be no impairment of the park's protected species whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Alternative B

Impact Analysis
<u>Mexican long-nosed bat</u> (*Leptonycteris nivalis*)
More natural and prescribed fire is proposed under Alternative B outside the bats seasonal stays from mid May to late July in the park. Alternative B provides the option of prescribed burns to lower fuels if deemed necessary.

Mitigation actions are the same as the No Action Alternative.

<u>Black-capped vireo</u> (*Vireo atricapillaus*)
Under Alternative B, more low and medium intensity natural and prescribed fire will be allowed in the park to reduce fuels and quickly allow fire to resume its role in the landscape. Vireo experts met in the park in June-July 2004 to identify the best strategies for the bird's protection. A mix of non-fire treatments, prescribed burns, monitoring and research was proposed.

Mitigation actions are the same as the No Action Alternative.

<u>Chisos Mountain Hedgehog Cactus</u> (*Echinocereus chisoensis* var. *chisoensis*)
Under Alternative B, more natural ignitions will be allowed to burn across the park under flexible criteria governing decisions on fire. Prescriptions are broad to allow natural fires to burn at low to moderate intensity. While fires are allowed under these Alternatives, fires in cactus habitat have been uncommon due to sparse, discontinuous fine understory fuels. However, movement of buffelgrass into nearby arroyos and around some populations increases fuels, flammability and the potential for injury from fire.

Mitigation actions are the same as the No Action Alternative.

<u>Guadalupe Fescue</u> (*Festuca ligulata*)

Under Alternative B fire may sweep through the entire population with unknown consequences.

Southwestern Willow Flycatcher (*Empidonax trailii extimus*)
Under Alternative B, the use of agreements with neighbors could lead to larger burn areas as fires are allowed to burn to natural barriers such as the river, roads or canyon walls. The trade off is maintaining potential habitat versus safety and firefighting effectiveness.

Northern Aplomado Falcon (*Falco femoralis septentrionalis*)
Alternatives B both allow more fire across the park with potentially beneficial effects on grasses and prey for this species.

Big Bend Gambusia (*Gambusia gaigei*)
Decades of suppression and abundant vegetative growth fed by springs have led to accumulations of fuels in some area around the ponds. Prescribed burns around the ponds in 2003 to reduce fuels were difficult to control. Other non-fire thinning and mechanical reduction followed by burning of slash piles may be one way to reduce risks associated with burning. Some fuel reduction is planned to lower hazards in nearby campgrounds.

Bunched Cory Cactus (*Coryphantha ramillosa*)
Alternatives B allow more fire across the park. Low discontinuous fuels on limestone reduce the likelihood of intense or widespread fire under either alternative.

Lloyd's Mariposa Cactus (*Sclerocactus mariposensis*)
Alternative B would allow natural fires to burn. However, fires are uncommon because fine fuels that facilitate the spread of fire are low and discontinuous.

Hinckley's Oak (*Quercus hinkleyii*)
Same as Alternative A.

Cumulative Effects
Cumulative effects are the same as the No Action Alternative.

Conclusion
Allowing more low and moderate intensity wildland fire and additional prescribed burns lessens fuels and the likelihood of adverse effects to plant and animal species and habitat from high-severity fire. These are indirect long-term minor to moderate and beneficial.

Under Alternative B, there would be no impairment of the park's protected species whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Alternative C

Impact Analysis
Mexican long-nosed bat (*Leptonycteris nivalis*)
Alternative C allows for prescribed burns to reduce fuels and provides the option of research burns to improve foraging habitat if deemed necessary. This Alternative is the preferred scenario as fuels and plant populations are assessed before any decision to conduct prescribed or research burns, fires would be reintroduced carefully to minimize agave mortality, and a natural fire dynamic gradually restored.

Mitigation actions are the same as the No Action Alternative.

Black-capped vireo (*Vireo atricapillaus*)
Under Alternative C, the preferred Alternative, more natural fire and prescribed fire will be allowed in the park as for Alternative B. However, fire will be allowed into areas based on the results of research burns that identify fire effects and dynamics and answer management questions.

Mitigation actions are the same as the No Action Alternative.

Chisos Mountain Hedgehog Cactus (*Echinocereus chisoensis var. chisoensis*)
Under Alternatives B and C more natural ignitions will be allowed to burn across the park under flexible criteria governing decisions on fire. Prescriptions are broad to allow natural fires to burn at low to moderate intensities. While fires are allowed under these alternatives, fires in cactus habitat have been uncommon due to sparse, discontinuous fine understory fuels. Movement of buffelgrass into nearby arroyos and around some cactus populations however, increases fuels, flammability and the potential for injury from fire.

Mitigation actions are the same as the No Action Alternative.

Guadalupe Fescue (*Festuca ligulata*)
Under Alternative A, duff levels will continue to increase and possibly interfere with seedling establishment. Under Alternative B fire may sweep through the population with unknown consequences. Under the preferred alternative, Alternative C, a small research burn may be considered to identify germination and establishment rates as most grasses evolved in association with fire.

Southwestern Willow Flycatcher (*Empidonax trailii extimus*)
Under Alternative C the use of agreements with neighbors could lead to larger burn areas as fires are allowed to burn to natural barriers such as the river, roads or canyon walls. The tradeoff is loss of potential habitat versus safety and firefighting effectiveness.

Northern Aplomado Falcon (*Falco femoralis septentrionalis*)
Both Alternatives B and C allow more fire across the park with potentially beneficial effects on grasses and prey for this species.

Big Bend Gambusia (*Gambusia gaigei*)
Decades of suppression and abundant vegetative growth fed by springs have led to accumulations of fuels in some areas around the ponds. Prescribed burns under Alternative A in 2003 around the ponds reduced fuels but proved difficult to control. The ponds proximity to a high-use camping area maintains the risk of fire from carelessness. Alternatives B and C allow more fire across the park reducing fuel levels including the nearby campsite.

Bunched Cory Cactus (*Coryphantha ramillosa*)
Alternative C is the same as Alternative B.

Lloyd’s Mariposa Cactus (*Sclerocactus mariposensis*)
Alternative C is the same as Alternative B.

Hinckley’s Oak (*Quercus hinkleyii*)
It is unlikely that the oak is present in the park as it has extremely distinctive foliage but has not been found.

Cumulative Effects
Cumulative effects are the same as the No Action Alternative.

Conclusion
Reduction of fuels across the park reduces fire intensity – a direct minor beneficial effect. Applying research results to manage habitats of protected species is a long-term direct beneficial effect.

Under Alternative C, there would be no impairment of the park's protected species whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Impact Topic (6): Cultural Resources

Fire may help reduce hazard fuels, maintain historic views and ethnographic resources, but can also remove plant populations that are important as ethnographic resources, damage and destroy structures and artifacts, and cause adverse changes to significant vegetative components of cultural landscapes.

The rich cultural history of Big Bend National Park is contained in the archeological record and in numerous historic buildings, sites, and settlements. The park as a whole is itself a complex cultural landscape characterized by visible effect of human influence on the natural environment as reflected in communities, small farming settlements, ranch sites, over 450 individual buildings and ruins, extensive farmlands with vernacular irrigation features, and a widespread network of roads and trails. The four main resource types include historic structures, cultural landscapes, archeological resources and ethnographic resources. Fire and fire management activities affects these types of cultural resources very differently.

Greatest damage can occur to historic buildings containing combustible materials. Under extreme fire temperatures, metals and glass melt, ceramics crack and vitrify. Structural integrity of these artifacts is impaired at 232 C and at higher temperatures pollens and other woody materials (which enable dating) are consumed or transformed (Jones, 2002). At temperatures greater than 135 C solder joints in metal cans melt and mortar joints in masonry walls begins to spall. These sites are also damaged by smoke, suppression activities and post-fire erosion, and damage to buildings jeopardizes National Register standing. The fire program sought specific guidelines from the staff cultural resource specialist (CRS) to reduce risk to this group of cultural resources.

The most important consideration in planning fire activities is that of protecting archeological context. The significance of sites, site features, and artifacts is in the degree of integrity of archeological context. Any activity that dislodges features or artifacts from their original location and context changes the scientific interpretation of the site. Any activity that alters the original condition of the site or the cultural materials within it potentially reduces the scientific values which qualify the site for the National Register. Prehistoric archeological sites are presumed to have burned occasionally. Studies in New Mexico show that damage can occur as deep as 20cm into the soil and substantial damage at all fire intensities (Lentz et al. 1996). Fire that burns woody stems of plants growing in prehistoric hearths introduces new carbon into the feature as the plant base decays and debris falls into the depths of the feature, which potentially contaminates radiocarbon dating of the feature. Reducing flammable brush can contain risks from fire, but the removal of the vegetative cover from a site exposes site features and the increasesd visibility increases the potential of damage from vandalism and theft. Managers must weigh these advantages and disadvantages during fire planning. Archeological identification surveying prior to prescribed burns will slowly identify additional sites within the park.

Vegetation that covers sites and cultural landscapes can screen these sites from view and protect them from the erosive force of rain and sun. An important character defining component of cultural landscapes are the historic plantings placed there by the site occupants. It is important to exclude these vegetative components from damage or loss from either wildland fire or prescribed burning activities. Plants can also undermine building foundations, and alter historically used springs. Water erosion and fire suppression activities place cultural landscapes at risk.

Ethnographic resources include plants, animals, landscapes or sites that held significance for American Indians. Whether the maintenance of these resources depended upon the deliberate use of fire is unclear but Cabeza de Vaca noted in 1528, that Indians use fire sticks to ignite plains and timber to drive out game (in Kozlwoski and Ahlgren 1974:392). Indscriminant removal of or alteration of plants from a traditional gathering site must be avoided during prescribed fire planning.

Assessment Methodology

Information in this section was developed primarily from the detailed analysis of cultural resources listed as Appendix 11, from the draft GMP (2003), technical literature, and staff at the park. Cultural resources in the park occur in all of the FMUs. The treatment of the cultural resource is determined by the nature of the resource and not by the FMU. Consequently, suggested treatments in Appendix 11 are grouped primarily according to resource type.

Intensity of effects for cultural resources is defined as:

Negligible: Effects are at their lowest level. There are no perceptible consequences to archeological sites, historic structures or cultural landscapes.

Minor: Adverse effects would be confined to a small area with little loss of important archeological information; non-measurable loss of defining characteristics of historic buildings or cultural landscapes. Beneficial impacts include stabilization of sites.

Moderate: Adverse effects would be disturbance to a site without loss of important archeological information or character defining features of historic structures or landscapes. These would still be eligible for the National Register. Beneficial impacts include stabilization of a site or rehabilitation of a landscape while preserving its character-defining features.

Major: Adverse effects include disturbance of a site so that much of the important information is lost, the integrity of buildings or cultural landscapes are damaged and the site no longer fulfills requirements for National Register status. Major beneficial actions include the intention to preserve a site and restoration of a building following Secretary of the Interior's Guidelines for Treatment of Historic Properties.

Impairment: A major, adverse effect to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Impact Duration Definitions:

Duration of impacts to cultural resources is not usually considered under the National Historical Preservation Act. Direct impacts are usually adverse and permanent. Landscapes may recover and even benefit from fire and fuel reduction.

Alternative A

Impact Analysis

Under Alternative A, a prescribed burning and fuels reduction program has been developed over the past 20 years to protect developments. Cultural resources have yet to be included under this regime because of limited resources and lack of understanding about how to use the program for best results. The park is currently assessing fuels around particular types of resources, historic buildings, cultural landscapes, ethnographic resources, and archeological sites. There are no blanket prescriptions because all types of resources are found throughout the park in differing types of vegetation and subject to differing risks from fire. Therefore, fire treatment is site-specific and must be tailored to the nature of each individual site. Wherever possible general prescriptions are developed to treat the different resource types and those resources on the Register of National Historic Historic Places. Overall, strict criteria governing fire in the park has likely protected many structures but fuels continue to build up (particularly in the Chisos), which increases flammability and fire temperatures.

Estimates of possible cultural resource sites in the park exceed 26,000, which make accurate estimates of impacts difficult without surveys. The most important consideration in planning fire activities is that of protecting archeological context. The significance of sites, site features, and artifacts is in the degree of integrity of archeological context. Any activity that dislodges features or artifacts from their original location and context changes the scientific interpretation of the site. Any activity that alters the original condition of the site or the cultural materials within it potentially reduces the scientific values which qualify the site for the National Register. Firelines and spike camps placed under emergency conditions may result in direct, adverse long-term impacts such as displacing artifacts from their original archeological context, and damage from crushing, spalling, cracking or consumption of materials.

Mitigation actions are: locate and identify sites vulnerable to fire effect; manually or mechanically reduce fuels; construct fire breaks around registered sites; use minimum impact techniques; ensure an archelologist or similarly qualified resources person is consulted during fires.

Cumulative Effects

Cumulative effects include:

- Construction of building and trails could have minor adverse effects minimized by surveys.
- Past and future prescribed burns, wildland fire use and non-fire fuel treatments may have adverse minor impacts, minimized by surveys and use of resource experts.
- Continued fuel accumulations in the Chisos, and expansion of exotic plants may lead to hotter burns and cause minor adverse effects.
- Revegetation of natives may reduce fuels leading to minor beneficial effects.
- Past and future flood and erosion events may have moderate to major adverse impacts.
- Expanded interpretive and education programs may lead to minor beneficial effects.
- Ground disturbance during suppression and hotter fires would result in minor direct and indirect adverse effects. Under Alternative A (No Action), cumulative impacts could be more intense because of the increased potential for high-severity fires.

Conclusion
Under Alternative A, minor to moderate beneficial impacts are likely to known sites. Impacts are likely to be localized and long-term. Under Alternative A, there would be no impairment of the park's cultural resources because there would be no major adverse impacts to *known* resources whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Alternative B

Impact Analysis
Allowing more prescribed and natural fire across the park increases the opportunity for fire to damage known sites and for undocumented sites to be damaged by fire control activities. Reducing fuels throughout the park is likely to result in minor to moderate direct beneficial effects for cultural resources over the short-term. The length of benefits depends on frequency of burns, their intensity, and control methods. Unknown archeological sites are at moderate adverse risks from suppression activities.

Mitigation actions are the same as Alternative A with the addition of allowing fire to burn to natural barriers along the park border. Allowing fire to extinguish naturally would reduce damage from suppression.

Cumulative Effects
Culumlative effects would initially be the same as Alternative A until fuels are reduced in the Chisos.

Conclusion
Alternative B is likely to result in long-term beneficial effects as fuels are reduced across the park and treatments of specific sites are implemented. Effects on unknown sites cannot be easily ascertained but prehistoric sites that have burned previously likely will not be damaged further. Greatest risks are from suppression activities.

Under Alternative B, there would be no impairment of the park's cultural resources because there would be no major adverse impacts to *known* resources whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Alternative C

Impact Analysis
Under Alternative C, developed areas remain protected through prescribed burning and no-fire treatments, and an expanded monitoring program builds knowledge of fire effects. More fires will be allowed to burn elsewhere in the park under prescriptions and may cause minor direct adverse effects over the short-term as archeological sites are blackened and exposed. Like Alternative B, suppression and control activities could inadvertently cause adverse effect to unknown prehistoric archeological sites. Increased burns using low intensity fire treatment will reduce fuel levels leading to lower levels of risk to cultural resources from high-intensity fires.

Mitigation actions are the same as Alternative A with the inclusion of more sites found through surveys associated with increased prescribed burns and monitoring.

Cumulative Effects
Cumulative effects are similar to Alternative A. Adverse impacts from increased prescribed burning could be greater unless accompanied by surveys and minimum impact suppression techniques.

Conclusion
Implementing mitigative measures in conjunction with increased fire use in the park would keep minor adverse long-term impacts to a minimum.

Under Alternative C, there would be no impairment of the park's cultural resources because there would be no major adverse impacts to *known* resources whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Impact Topic (7): Watershed Effects

Fire can remove vegetation and organic matter, and followed by intense thunderstorms lead to loss of rare plant and animal species through erosion, debris flows, and siltation, the demise of relict forests, invasion by weed species, loss of wildlife habitat, and substantial long-term changes in the vegetation.

The Chisos Mountains are a premier destination for visitors to Big Bend. Camping in the mountains is the most popular recreational activity (GMP 2003), and one the park wants to maintain. The sparsely vegetated lowland desert grasslands are a sharp contrast to the mountains and a reminder of the predominant climate throughout this region. Staff believe the region is significantly altered since grazing but some areas may have the potential to be restored, which would represent a significant scientific contribution to desert grassland restoration.

Post-fire impacts on watersheds are influenced by many factors. Fire intensity, rainfall intensity and amount, slope, soil texture, water depth and holding capacity, rock fractures and outcrops, and amount of vegetation and charred material will affect infiltration, runoff, and potential erosion. Vegetation removed by fire is no longer available to break the erosive impact of rain, nor utilize water that infiltrates soils. Severe fires burn the tree canopy and soil seedbeds, and invasive plants better adapted to drier soils may colonize exposed sites. During fire, soil surface temperatures are high and dry out, which makes them initially hydrophobic and prone to runoff. Other effects are the release of nitrogen upon burning and stimulation of microbial activity upon exposure of soils to higher temperatures and oxygen. Post-fire temperatures of soil are elevated and may aid seedling germination with sufficient moisture (Scifres and Hamilton 1993). Erosion becomes a threat immediately following fire as intense thunderstorms may dislodge soil particles on bare steep slopes, which carries them into drainage lines and silting areas below. These flows could be short-lived but overwhelm seasonal drainages where mesic plant and amphibians live. Recovery may also be jeopardized by the changes in nutrient levels and ph within shallow ponds that become silted. The amount of erosion is influenced by rainfall intensity, permeability of the soil, and amount of vegetation, cobbles or rock on the surface. The intense summer rainfall is absorbed more readily by sandy, gravelly, and loamy soils than by fine-textured clays and silts, found in flatter areas and in depressions.

Assessment Methodology
Staff estimated likely impacts of erosion and debris flows on 11 watersheds with 6 major soil map units in the Chisos Mountains. The estimate of effects was based on soil type, slope, and rainfall conditions following a (1) high severity, widespread fire that could occur without fuels reduction, and (2) a moderate intensity fire, which is the upper limit of allowed fire conditions under the preferred alternative. Park hydrologist Jeffrey Bennett and soil scientist Lynn Loomis (USDA/NRCD Marfa, January-May 2004), provided guidance for this watershed evaluations.

Intensity of effects for watersheds is defined as:

Negligible: No runoff, debris flows, or perceptible effects on soils.

Minor: Perceptible but hardly measurable effects on soils or debris flow. Effects easily restored.

Moderate: Measurable and noticeable effects. Runoff causes erosion. Debris flows silt drainages and ponds. Restoration work required to prevent downcutting and siltation of drainages.

Major: Erosion is apparent and cannot be remedied easily. Debris flows have silted low lying areas. Soils and organic matter layer are removed. Restoration is extensive.

Impairment: A major, adverse impact to a resource or value whose conservation is (1) necessary to fulfill specific purposes identified in the establishing legislation or proclamation of Big Bend National Park; (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning documents.

Short-term: For the duration of the fire season.

Long-term: For the duration of the fire program or longer.

Alternative A

Impact analysis
Under Alternative A, restrictive go/no-go decision criteria mean most lightning ignitions are suppressed. The probability of widespread, high-intensity fire in woodlands and forests of the Chisos Mountains increases with the buildup of leaf and needle litter, downfall, ladder fuels and the closure of tree canopies. A high-severity, high-intensity fire would result in long-term, moderate to major adverse impacts on watersheds. The intensity and duration of rainfall, coupled with soil texture and depth, slope, rock fractures and outcrops would determine erosion and debris flows following fire. Intense thunderstorms may silt drainages containing rare species. Sparse vegetation in the lowland deserts means most fire is driven by high winds and results in a mosaic of burned and unburned areas.

Mitigation actions are: prescribed low-intensity burns in the Chisos; identifying firebreaks, staging camps and spike camps ahead of fires to minimize ground disturbance from suppression activities; uppressing fire in Upper Pine Canyon, a Research Natural Area, where fire would interrupt long-term ecological studies. There are few options for reintroducing fire due to restrictive decision criteria on natural ignitions and treatment of the Chisos as a suppression zone. Staff have been reluctant to explore grassland restoration in lowland deserts without a clear research agenda.

Cumulative Effects
Cumulative effects that would increase adverse effects in the Chisos are the construction of additional hiking trails, and continuing buildup of fuels. No action in the lowland deserts may result in continual erosion, the rate dependent on precipitation, climatic cycles, and periodic thunderstorm events. Under Alternative A, cumulative impacts could be more intense in the Chisos because of the increased potential for high-severity fires.

Conclusion
Fire management suppression impacts to watersheds in the Chisos are likely to be adverse, minor to moderate and long-term while suppression continues, fuels build, and the potential for high-severity fire increases. The potential continues for moderate, adverse impacts to soil stability and debris flows following high-severity fire and summer monsoons. While suppression remains successful impairment is unlikely. Minor, adverse impacts are expected to watersheds in lowland deserts without restoration efforts.

Under Alternative A, because there would be no major adverse impacts to watersheds whose conservation is (1) necessary to the establishing legislation or proclamation of Big Bend National Park; or (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning document.

Alternative B

Impact Analysis
Under Alternative B, natural and prescribed fires are allowed to burn under prescription across the entire park up to buffered areas around developments. This alternative proposes rapid reintroduction of fire to park ecosystems to reduce high fuel loads in the Chisos woodlands and forests. This would also regenerate plant communities where fire occurred naturally. The prescriptions ensure that initially burns are low- to moderate-intensity until fire effects are understood. Staff would review of fire effects annually and adjust intensity and season to allow more lightning ignitions just prior and during summer monsoon when most fire historically occurred.

Impacts are expected to be short- to long-term and minor to moderately beneficial in reducing fuels and regenerating plant communities. There may also be short- to long-term minor to moderate adverse effects to views and soils in the Chisos as vegetation reestablishes.

Mitigation actions are similar to Alternative A with the addition of post-fire monitoring of prescribed and natural ignitions, and annual review of prescribed burns and fine-tuning of prescriptions.

Cumulative Effects
Alternative B would have fewer adverse long-term effects than Alternative A. Allowing fire in the Chisos at low and moderate intensities should lessen cumulative effects of fuels on the likelihood of high-severity fire.

Conclusion
Under Alternative B adverse impacts to the Chisos Mountain watersheds would be minor to moderate and short-term. Minor adverse impacts from fire are likely in lowland desert areas. Beneficial impacts are expected over the long-term for watersheds in the Chisos. Extreme fire events outside prescription before fuels can be reduced would create moderate to major direct adverse impacts over the short and long-term.

Under Alternative B, because there would be no major adverse impacts to watersheds whose conservation is (1) necessary to the establishing legislation or proclamation of Big Bend National Park; or (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning document.

Alternative C

Impact Analysis
The Zone of Special Treatment under Alternative C calls for research fires and careful management of lightning ignitions within prescriptions. Research results potentially allow fires to be managed in

sensitive habitats and watersheds with less damage than high-severity fire. Natural fire reduces fuels and potential moderate adverse impacts to watersheds. Application of research burn knowledge is expected to yield short to long-term direct and indirect beneficial impacts to watersheds.

Mitigation actions are similar to Alternative B with the additions of: erecting brush or other structures to limit erosion and avoid silting rock pools and drainages; reestablishing native plants where needed; preventing the spread of exotics particularly into sites where native species are establishing; allowing natural ignitions in desert scrub and grasslands to slow the shrub encroachment; establish small research burns in areas where soils appear stable, seed sources of desired species are present, and knowledge of 'fix-it' techniques are known if the burn results are unsuccessful; use brush and other appropriate techniques to slow overland flows, increase infiltration, cool soil temperatures and generally improve conditions for germination and establishment of plants; control exotics that may have invaded scrub or grasslands.

Cumulative Effects
Cumulative effects may be similar to Alternative B but take longer to accrue. Research results in the Chisos from prescribed burns would then be reapplied under suitable climatic and management conditions. Any recovery in lowland deserts will be shaped by wet climate cycles more than fire events. These effects would cumulatively result in minor to moderate direct and indirect beneficial short-term effects to watershed integrity and long-term benefits to nutrient cycling.

Conclusion
The preferred alternative would result in long-term moderate direct and indirect beneficial effects. Low to moderate intensity research burns, assessment of fire effects and gradual reintroduction of natural ignitions based on this knowledge is expected to safely reduce fuels and preserve resources valued by the public. Fire management guided by research into restoration of lowland deserts may have direct and indirect benefits to watersheds over the long-term.

Under Alternative C, because there would be no major adverse impacts watersheds whose conservation is (1) necessary to the establishing legislation or proclamation of Big Bend National Park; or (2) key to the natural or cultural integrity of the park; or (3) identified as a goal in the park's general management plan or other relevant NPS planning document.

Impact Topic (8): Resources for the Fire Program

Big Bend is a large park with a relatively small fire program. The emphasis on the proposed action alternatives is to (1) reduce fuels to safe levels through a mix of wildland fire use, prescribed burns, and no-fire thinning, and to (2) better understand fire effects in a number of sensitive habitats. Staffing levels currently dictate that some routine tasks in most divisions are deferred. An increase in routine fire operations would drain the already taxed staff and suggests additional human resources are needed to support the increased level of fire program activities. Attempting to "make-do" with existing staff can lead to inadequate reporting, insufficient supervision of staff new to tasks, stress and burnout, and failure to adequately monitor pre-fire and post-fire burn sites for cultural resources and natural resource data. In addition, lack of time and resources may result in new data not being translated into management decisions. Currently, the park can cope with wildland fires to a limited degree with initial attack and confinement operations, and some extended attack efforts depending on the circumstances (for example: personnel availability, visitation numbers, risks, regional readiness, and logistical support).

Assessment Methodology
Evaluation of existing resources and proposed needs under action alternatives was obtained primarily from the Fire Management Officer based on experience catering to prescribed and wildland fires under the No Action Alternative (Alternative A).

Intensity of effects for resources for the fire program is defined as:

Negligible: Impacts are at the lowest levels of detection with no additional staff or funding required.

Minor: Detectable effect but additional staff and funding can be found from within existing park resources.

Moderate: Effect is such that additional outside resources are needed for fire activities and outside funding is required to support such activities on a seasonal basis.

Major: Additional permanent staff and resources are required to carry out fire management activities.

Short-term: Duration of the planning and execution of fire program activities.

Long-term: Long-term effects of insufficient resources extend beyond the FMP and cumulate in patchy research results, sporadic fulfillment of fuels assessment and fuels reduction, inability to provide monitoring timely or accurate monitoring data, all factors that limit knowledge for future decision making around fire effects.

Alternative A

Impact Analysis
The major thrust of the fire program under Alternative A is protection of developments through prescribed burns and mechanical and manual thinning. The park has maintained a 'safety by suppression' approach to lightning ignitions. Fuels continue to buildup in the Chisos and the park lacks the resources to confine or control large fires or a fire that spreads rapidly with multiple resource type requirements—engines, crews, and aircraft. Several years of above average rainfall (2002, 2003) combined with fuel buildup in the Chisos and unfilled key personnel positions, creates the potential for a high-intensity fire that would strain existing resources. The current alternative has contributed to direct and indirect moderate adverse impacts in the short-term and the long-term. How this situation is resolved adverse beneficial, depends on the level of training, availability of funding and personnel for seasonal firefighting, ability to undertake higher risk operations, and whether current key positions are filled, such as Engine Boss and Crew Boss.

Mitigation actions are: recruitment and training of seasonal Los Diablos firefighters from Mexico; training of existing staff; and sharing of trained staff from other departments, agencies and the region. Staff sharing occurs on a regional basis during extreme fire events.

Cumulative Effects
Cumulative effects under Alternative A include the diversion of fire staff assigned to other duties such as trail maintenance or interpretive activities due to rising visitation. The impact of this Alternative will vary depending on the year, number of fires, weather conditions in addition to regional conditions. Severe fire conditions in combination with increased visitation would create moderate adverse seasonally short- and long-term effects.

Conclusion
Under the current management direction there would be long-term minor to major adverse impacts to park values and resources as existing staff are called to meet increasing numbers of emergency fire situations.

Alternative B

Impact Analysis
More natural fire is expected in the park under Alternative B requiring intermittent non-predictable staffing needs. The fire program can create scenarios identifying needed staff and other resources but cannot predict which scenario will actually occur. Additional protection activities are planned for developments, selected cultural resource sites, and sensitive species habitats. Communications with neighbors about changing boundary agreements to create safer conditions for fire fighters and reduce damage to soils and vegetation – will take time. Effects depend on size, intensity and location of fire, the number of fires within a particular period and available support from other agencies and the region. Short-term minor to moderate direct adverse impacts are expected to resources if fires are large or occur before sufficient trained personnel and resources can be utilized.

Mitigation actions are: increasing preplanning such as fuels assessment prior to burning; allowing only low to moderate intensity burns; developing buffer areas and defensible space; identification of potential firelines and spike camps; use of a resource advisors; fine-tuning prescriptions; and recruitment and training of seasonal firefighters and permanent staff.

Cumulative Effects
Cumulative effects are similar to Alternative A but could be more adverse unless additional resources are available to meet higher demands for fuels reduction and more natural fire. Moderate direct adverse short to long-term impacts would be expected in high fuel areas of the park as staff are redeployed to cope with more fire related demands.

Conclusion
Under Alternative B, more frequent and larger natural fires, and more fuels reduction treatments are expected to tax existing staff, seasonal firefighters, engines, and equipment. Shifting from suppression under Alternative A to more routine fire events will require reassignment of staff priorities and/or hiring of additional staff with sufficient engines, equipment and safety training. Depending on how resource needs are met, these changes could be minor to moderate adverse (if met within the park) or beneficial (additional hires from outside the park) with direct and indirect long-term effects to park resources.

Alternative C

Impact Analysis
Under Alternative C, more natural and prescribed burns are allowed across the park after fuels assessment. Protection of developments will continue with a program of prescribed burns, thinning, mowing, and herbicide application. A unique aspect of this alternative is the use of research burns to better understand fire effects in sensitive habitats, particularly the woodlands and forests of the Chisos. Scientific design, pre-fire and post-fire monitoring, and evaluation of results will enable outcomes to be incorporated into management practices for these sensitive resource areas. Expanding, developing and maintaining this three-pronged approach to fire management will require a considerable change in direction for fire staff and managers. Not only will additional resources be required but also time for the planning, evaluation, and interpreting results into adaptive management.

Short to long-term minor to moderate direct and indirect adverse effects are expected if staff are reassigned from existing positions to share additional tasks. A benefit is that additional trained personnel available to assist with fire activities. The level of skill and experience for some tasks, such as scientific design of research burns, will required specialized backgrounds. Burns conducted in rugged terrain or around rare or threatened habitat may require that ignitors and/or firefighters receive additional training from specialized crews such as the “Hot Shots.”

Mitigation actions are: the recruitment of additional Los Diablos to handle prescribed and natural ignitions on a more routine basis in the park; filling key positions within the fire program including Engine Boss, Crew Boss and fuels specialist; determining priorities and methods for reducing fuels around cultural resource sites; and determining specific questions to be answered by research burns.

Cumulative Effects
Cumulative effects of Alternative C on park resources for the fire program will depend on the frequency, timing, and severity of fires. Prescribed burns will mostly occur outside the fire season when pressures on park fire crews are lowest. Allowing for more ignitions during fire season will increase pressures on permanent and seasonal resources within the park and regionally. In an emergency staff would be deployed from existing duties to provide logistical support as needed. If support is needed frequently, other planned projects such as construction of buildings and trails would be delayed and may incur additional costs – a short-term direct minor to moderate adverse impact.

Conclusion
Under Alternative C, impacts to resources for the current fire program and staffing levels are likely to result in moderate direct and indirect adverse effects. The expected increase in actions cannot be met without additional input from scientists for research burns, cultural resource specialists for protection of specific sites, knowledge of fire effects across the park (requiring pre-monitoring and post-monitoring (whenever possible)), and additional permanent or seasonal staff. These requirements are likely to instigate long-term changes in the park fire policy to enable adaptive management of resources and values.

Chapter V: Consultations and Preparers

Preparers

Alex, Betty, *GIS Specialist, Big Bend National Park*. BS in Wildlife Biology Corpus Christi State University. Five years sedimentation scientist with USGS, 24 years with NPS, 11 as activities clerk, 13 as GIS specialist. Performs spatial analyses, creates maps and coordinates mapping of all park resources; special interest in rare plants. Compiled all maps for this project and shaped rare plants information.

Alex, , *Cultural Resource Specialist, Big Bend National Park* **-** BA in Cultural Anthropology from Stephen F. Austin University in Nacogdoches, Texas. 36 years experience in the field; contract archeologist for municipalities and mines in Texas and Louisiana; research assistant, supervisor for excavations and field supervisor; 20 yrs with NPS at Big Bend NP. Lead on cultural resource issues.

Bennett, Jeffery, *Hydrologist, Big Bend National Park.* BS from Sul Ross University, Alpine, TX in Earth Sciences, MS in Geology from Northern Arizona University, Flagstaff, AZ. 4 years soils/beach erosion and 5 years water quality in Grand Canyon NP, 3 years groundwater hydrogeologist, 1½ years at Big Bend NP. Lead on watershed effects.

Davila, Vidal, *Chief of Science and Natural Resources, Big Bend National Park.* BS in Recreation and Parks Administration from Texas A & M University. Management of cultural and natural resources at Armistad Recreation area 3yrs, Santa Fe Regional Office 1 year, Guadalupe NP 6 years, Great Basin NP 5 years and Big Bend NP a total of 15 years. Lead on compliance issues and correspondence with agencies.

Gatewood, **Richard,** *Fire Ecologist, National Park Service, Chihuahuan Desert Units*. Ph.D Disturbance and Restoration Ecology, Colorado State University. 4 years Ecologist, State of Texas; Research Associate, USDA Forest Service Rocky Mountain Experiment Station; 4 years Ecologist Bandelier National Monument. Lead on fire ecology and fire effects research and monitoring for the park. Technical representative between Big Bend NP and University of Arizona.

Moodie, Susan, *Research Associate, University of Arizona School of Renewable Natural Resources*. Ph.D. Candidate Arid Lands, University of Arizona. 5 years technical advisor, policy development community-based ecological restoration, Australia; 2 years organic market gardener New Mexico, 3 years entomology research, 2 years farming systems research Malawi, Africa, 4 years teaching and curriculum development. Lead coordinator for this EIS and associated compliance documents.

Morlock, John, *Fire Management Officer, Big Bend National Park*. BS in Conservation of Natural Resources from Texas A & M University; 7 years as River Ranger at Big Bend NP; 16 years as FMO at Bryce Canyon, Utah, El Malpais, New Mexico and Big Bend NP. Lead on fire management issues.

Skiles, Raymond, *Senior Wildlife Management Officer, Big Bend National Park.* B.S in Wildlife Ecology from Texas A & M University. Seasonal worker on interpretations, law enforcement and natural resources at Big Bend NP, Death Valley NP, Colorado NM, and Shenandoah NP; 1 year Washington D.C. public affairs; 17 years Big Bend as Wildlife Biologist. Lead on wildlife, federally listed species and fire effects.

Sirotnak, Joe, Botanist, Big Bend National Park. Ph.D in Ecology, Idaho State University. 4 years Botanist at Big Bend NP; 1 year Ecologist at Great Basin NP; 6 years Research Assistant in Ecological Research Idaho State University; I year Biological Technician; 1 year Research Biologist, Lead on vegetation categorization, federally listed plant species and fire effects; co-developed research approaches.

Reviewers:

Internal Review
Gebow, Brooke, *Senior Research Specialist, University of Arizona School of Renewable Natural Resources*. MS in Ecology and Evolutionary Biology from University of Arizona, 6 years energy consulting, 12 years free-lance science writer, 4 years Tucson Botanical Gardens, 5 years project support for UA USGS Sonoran Desert Research Station. Cooperator with the NPS to coordinate production of a number of NPS Fire Management Plans and associated compliance documents.

Peer Review
Lujan, John, *Superintendent Guadalupe Mountains NP*. BA in History from Sul Ross State University in Alpine, Texas: 27 years with the NPS at eight park units representing cultural, natural and recreational areas. Fire Management background includes fire fighting experiences across the west and southeast. Oversight of the development of the Interagency FMP between the NPS and the BLM.

Chronology

The preparation of this draft Environmental Assessment involved consultation between the NPS and UA partners, government agencies, and outside experts and researchers from December 2002 to December 2004. The chronology below identifies important scoping periods, meetings, and outside consultation.

12-11-02 12-12-02	Internal Scoping Meeting at Big Bend National Park; 18 staff present; goals and objectives of the fire program identified; issues and impact topics clarified using NEPA guidelines.
4-14-03	Notice of Intent to produce an Environmental Impact Statement for FMP published in Federal Register.
6-10-03 to 7-30-03	Newletter mailed to park mailing list and also posted on the Big Bend National Park website. Public scoping comment period; period extended as newsletter sent mid May to public, agencies, researchers.
5-28-03	Meeting of IDT at El Paso. Identify vegetation categories (start) and fuel models
6-26-03	Public Scoping Meeting, Sul Ross State University, Alpine, Texas 5-7 pm.
6-27-03	Public Scoping Meeting, Community Center, Study Butte, Texas 5-7 pm.
11-20-03	Intiate consultation with USFWS to conduct Biological Assessment (BA) under Section 7 consultation requirements.
1-1-04 1-2-04	Meeting at Big Bend NP. Identified prescriptions for alternatives and finalized vegetation categories under FMP; conservatin measures for BA.
1-04	List of tribal governments associated with park updated to seven.
1-27-04	First informal review of Biologial Assessment by USFWS.
5-18-04	Informal review of draft BA by Texas Parks and Wildlife Service
6-1-04 6-2-04	Meeting at Big Bend NP with vireo experts to determine conservation measures under the FMP: John Maresh, John Cornelius, Bill Armstrong.
5-04	Initiate consultation with TX SHPO for National Histoic Preservation Act Section 106 complainace
6-29-04 6-30-04	Meeting at Big Bend NP to develop fuels treatment program; identify watersheds at risk; develop research protocols; intiate maps
7-10-04	Second informal assessment of BA by US FWS
10-04	Internal review of BA by park
10-04	Internal review of Cultural Resource Component by park
12-04	Notice of Intent to change Environmental Impact Statement to Environmental Assessment appeared in the Federal Register.

6-05	Peer review by Superintendent of Guadalupe Mountains National Park
6 05	Biological Assessment submitted to USFWS for formal evaluation
6 05	Cultural Resource Component submitted to TX SHPO for formal evaluation
6-1-05	Environmental Assessment released for review.

The Draft EA will be sent to agencies, tribes, and organizations. It will be accessible to the public through the Big Bend National Park website and a paper copy will be kept in the park visitor center. Landowners adjacent to the park (for whom the park has an address) and other interested individuals wil be sent notification of the availability of the document, with information on how to obtain a copy. Public comments will be received for at least 60 days.

Following the public review period for the draft EA, a final EA will be developed that considers, addresses and seeks to resolve all substantive issues and comments raised by the public or agencies.

List of Recipients
The following will receive hard copies of the draft Environmental Assessment. A letter will be sent to the park's mailing list to inform interested parties of alternative methods of aquiring the DEA.

Carlsbad Caverns National Park\
Guadalupe Mountains National Park?
Big Bend Ranch State Park
Black Gap Wildlife Management Area
Sul Ross State Univeristy Library
Texas State Historic Preservation Office, Debra Beene
Texas Parks and Wildlife , Jackie Poole
U.S. Fish and Wildlife Service, Jana Milliken

Glossary

Appropriate Management Response (ARM)	Strategic and flexible response to fighting fire based on best information and experience available at the time; may include control (direct action to install firebreaks and stop a fire from spreading), containment (action on one or more sides of fire) or confinement (allowing a fire to burn to a barrier)
Biological Assessment (BA)	An assessment presented to U.S. Fish and Wildlife Service of effects on federally listed species, proposed listed species, or critical habitats of proposed federal actions that are not major construction projects (in this particular case, implementing a new FMP is the proposed action)
Biological Opinion (BO)	The opinion of the U.S. Fish and Wildlife Service on whether or not a proposed federal action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat
Context	The geographical or temporal environment of a proposed action, such that a change in the action relative to space or time might alter impacts
Control, contain, confine	A sequence of progressively less aggressive actions applied to wildland fire. *Control* consists of actions to suppress fire including installing firelines and suppressing hot spots, *contain* keeps fire within established boundaries and *confine* typically allows fire to burn itself out within a natural or constructed fireline.
Cultural Landscape	Landscapes as affected by people through time— the definition of such captures overlapping occupancy by different groups of people
Cultural Resources	Valued aspects of a cultural system that might be tangible (districts, sites, structures, objects)
Cultural Resources Component (CRC)	Document analyzing effects of the proposed action on cultural resources for review by the State Historic Preservation Office
Cumulative Effect	Effects of actions (those in the past, present, or reasonably foreseeable future) that have an additive impact on the resources affected by the proposed action
Debris Flow	“Rivers” of earth, rock, and debris saturated with water; one cause is intense summer thunderstorms following removal of organic matter from soils by fire
Direct Effect	An impact that occurs as a result of the proposed action or alternative in the same place and at the same time as the action
Duration	The length of time of effects of an action
Duff	Decomposing organic matter lying beneath the litter layer and above mineral soil
Ecoregion	A large-scale area with a common geological and biological history
Exotic Species (also non-native)	Species not native to a particular ecosystem
Fire break	A natural or manmade barrier to fire, such as a river, road, or excavated line, that is devoid of flammable vegetation
Fuel continuity	Describes how connected fuels are horizontally across the ground and vertically

	into canopies; continuous fuels support fire spread
Fire frequency/return interval/ fire cycle	The recurrence of fire in a given area/habitat over time
Fire intensity	The amount of energy released by the fire usually measured as per unit length of fire front; reported as low, moderate or high
Fuel moisture	Most important determinant of flammability; varies daily within plants but over a lifetime plants become drier and more flammable as they mature
Fire severity	Qualitative measure of mortality and survival on above ground plants and animals and below ground effects on loss of organic matter; determined by heat released; little organic matter is removed or tree canopy scorched under low severity, while high severity signals very hot burns removing soil organic matter and burning forest canopy
Fire Management Plan (FMP)	The plan that guides all fire-related activities at a park that is consistent with land and resource management plans and follows NPS guidelines
Fire Management Unit (FMU)	A delineated area of the park that permits particular fire management strategies
Fuel	Vegetation, both living and dead, capable of burning
Fuel management	The use of methods such as prescribed fire and manual and mechanical means to reduce flammable vegetation that accumulates over time
Impairment	Impacts on resources that negatively, significantly, and possibly irreversibly alter their character from the state that made them important to protect in a park
Ground fire	Burns down through the litter into the duff and organic matter; can kill roots and destroy soil seedbanks
Indirect effect	An impact that occurs as a result of the proposed action, but removed in time and space from the action
Intensity	Magnitude of effect, from low to high
Inter-disciplinary team (IDT)	Group of interdisciplinary specialists that identifies important issues, relationships, and alternatives for public scrutiny
Manual fuel reduction	Removal of vegetation or creation of fire breaks using hand tools and chainsaws
Mechanical fuel reduction	Removal of vegetation or creation of fire breaks by bulldozer or road grader
Minimum requirement	The lowest impact means of accomplishing a task, frequently considered with respect to wilderness
Mitigation	Modification of an action that lessens intensity of its impacts on a particular resource
Monitoring program	Collecting information in a systematic way on species, species distribution, growth, fuel loading and health, archeological remains, before and after prescribed burning and after natural ignitions
National Environmental Policy Act (NEPA)	The 1969 law that dictates the objective analysis and public scrutiny of the environmental as well as social and economic impacts of proposed federal

	actions and their alternatives prior to implementation
Natural resources	A feature of the natural (physical and biological) environment that has value to humans
No Action	Under NEPA, No Action continues the current planning and operational direction and provides a baseline against which other alternatives can be measured
Non-fire treatments	Removal of vegetation without using fire, most commonly through mechanical/manual means including mowing, slashing, chainsaws or herbicidal treatments
Non-native species	Species not native to a particular ecosystem (used like "exotic")
Prescribed fire	Fire ignited by management to meet specific objectives
Prescription	Measurable environmental criteria, particularly temperature, relative humidity, wind speed and direction, and fuel moisture, that define the conditions under which a fire would be ignited by management, guide selection of appropriate management responses, and indicate other required actions
Research burn	Prescribed burns with greater investment in examining, recording, analyzing, evaluating and applying monitoring results of fire effects and fire dynamics to management decisions
Resource advisor	An expert in a particular resource area (such as an archeologist or botanist) who is brought on site to advise fire crews relative to protecting sensitive resources
Rhizome	Creeping stem growing beneath the soil surface sending up new leaf shoots from nodes; characteristic of lechuguilla, saltcedar and Bermuda grass
Root crown	Mass of woody tissues from which stems and roots originate; usually applied to shrubs and herbaceous plants; often indicates drought tolerance and ability to resprout after fire
Scoping	Compilation of knowledge and opinions in order to properly develop and decide on alternative courses of action, both internally to the park and externally with the public
Sensitive species	Species sensitive to perturbation from the proposed action, frequently rare species that are federal or state-listed, proposed for listing, occurring in very few places, or particularly sensitive to the action's impacts
Species diversity	A measure of the number of species in an area (species richness) that also accounts for species abundance
State Historic Preservation Office	The state office overseeing protection of cultural resources
Succession	The natural evolution of biotic communities over time following disturbance
Suppression	All the work of extinguishing a fire beginning with its discovery, using confine, contain, and control actions
Thinning	Reduction of density of vegetation, frequently using non-fire means

Glossary

Timing	How effects vary depending on when the action takes place
U. S. Fish and Wildlife Service	U.S. Department of Interior agency charged with overseeing protection of threatened and endangered species
Unique Sites	Sites sufficiently uncommon such that their presence is a special feature of the park with intrinsic value and of interest to visitors
Unique Stands	Patches of vegetation that are uncommon in an area that may be relicts from an earlier age
Watershed	Land above a given point in a drainage that potentially contributes water to the streamflow at that point
Wilderness	Designated area managed to perpetuate natural processes and minimize human impacts
Wildland fire	Any fire except prescribed fire or fire in developments, that occurs in the wildland or backcountry
Wildland Fire Use (WFU)	Naturally (lightning) ignited fire managed to meet resource benefits

Literature Cited

Aldon, Earl F. 1975. Establishing alkali sacaton on harsh sites in the Southwest. *Journal of Range Management.* 28(2): 129-132.

Anable, M.E. M. McClaren, and G.B. Ruyle. 1992. Spread of introduced Lehmann lovegrass Eragrostis lehmanniana Nees. In Southern Arizona, USA. *Biological Conservation* 61:181-188.

Anderson, E.F., and R. Schmalzel. 1998. Study of the Bunched Cory Cactus (*Corypthantha ramillosa*). First Annual Report for FWS Agreement No: 1448-00002-96-0854. 38 p.

Anderson, E.F., and R. Schmalzel. 1997. Final Report on Lloyd's Mariposa Catus Survey (*Sclerocactus [Neolloydia] mariposensis*). Prepared for Joint Task Force Six.

Anderson, H. E. 1982. *Aids to determining fuel models for estimating fire behavior*. USDA Forestry Service General Technical Report. INT-122. Intermt. Forestry and Range Experimental Station, Ogden, Utah 84401.

Ahlstrand, G. M. 1981. High country fire history. P. 1–22 in G. M. Ahlstrand, principal investigator. Ecology of fire in the Guadalupe Mountains and adjacent Chihuahuan Desert. Carlsbad Caverns and Guadalupe Mountains National Parks, Carlsbad, NM.

Ahlstrand, G. M. 1982. Response of Chihuahuan Desert mountain shrub vegetation to burning. *Journal of Range Management* 35:62–65.

Baisan, C.H. and T.W. Swetnam. 1995. Sandia/Manzano fire history final report. Tucson, AZ: Laboratory of Tree-Ring Reseach, Univeristy of Arizona, Tucson.

Baker, W.L. and D.J. Shinneman. Fire and restoration of pinyon-juniper woodlands in the western United States: a review. *Forest Ecology and Management* 189(2004):1-21.

Bell, G. P. 1986. Ecology and management of *Arundo donax*, and approaches to riparian restoration in southern California. The Nature Conservancy. (http://tncweeds.ucdavis.edu/esadocs/arundona.html).

Betancourt, J., T. Van Devender, and P. Martin. 1990. *Packrat Middens: the last 40,000 years of biotic change.* Tucson, AZ: University of Arizona Press.

Big Bend National Park. February 2003. Draft General Management Plan/ Environmental Impact Statement. National Park Service, Department of the Interior.

Big Bend National Park. 2000. *Business Plan*. 21p.

Booth, T.P. 2001. Impacts of Global Change on Big Bend National Park, Texas. Univeristy of Arkansas. 24 p.

Bray, W.L. 1901. The Ecological Relations of the Vegetation of Western Texas. *Botanical Gazette* 32(4): 262-291

Brooks, M. L. and D. A. Pyke. 2001. Invasive plants and fire in the deserts of North America. Pages 1–14 in K. E. M. Galley and T. P. Wilson (eds.), Proceedings of the Invasive Species Workshop: The Role of Fire in the Spread and Control of Invasive Species. Fire Conference 2000: The First National Congress on

Fire Ecology, Prevention, and Management. Miscellaneous Publication No. 11. Tall Timbers Research Station, Tallahassee, FL.

Brown, D. E. 1994. *Biotic Communities. Southwestern United States and Northwestern Mexico.* Salt Lake City: University of Utah Press.

Brown, J. 2000. Ecological Principles, Shifting Fire Regimes and Management Considerations. In Wildland Fire in Ecosystems. Effects of Fire on Flora. USFS. Rocky Mountain Research Station. General Technical Report RMRS-GTR-42 volume 2. pp. 185-203.

Cable, D.R. 1975. Influence of precipitation on perennial grass production in the semidesert southwest. *Ecology* 56:981-986.

Carpenter, A.T. 1999. Element stewardship abstract for *Tamarix* spp. The Nature Conservancy. (http://tncweeds.ucdavis.edu/esadocs/documnts/tamaram.pdf).

Council on Environmental Quality (CEQ). 1978. Regulations for Implementing NEPA. (http://ceq.eh.doe.gov/nepa/regs/ceq/toc_ceq.htm).

Cornelius, J.M. 1988. Vegetation response to a fire in a northern Chichuahuan desert grassland. Ph.D. Thesis. New Mexico State University, Las Cruces, NM.

Dick-Peddie, W.A. 1993. New Mexico Vegetation: past, present and future. Albuquerque: University of New Mexico Press.

Dick-Peddie, W.A and M. S. Alberico (1977). Fire Ecology Study of the Chisos Mountains, Phase 1. Chihuahuan Desert Research Institute. Records at Big Bend National Park.

Drewa, P.B., nad K.A. Havstad. 2001. Effects of fire, grazing, and the presence of shrubs on Chihuahuan desert grasslands. *Journal of Arid Environments*. 48: 429-443.

Elias, S.A. 1997. *The Ice-Age History of Southwestern National Parks*. Washington; London: Smithsonian Institution Press. 200p.

Fulcher, W. 1959. *The Way I Heard It*. Austin, TX: University of Texas.

Fule, P.Z., A.E. Cooke, T.A. Heinlein, and W.W. Covington. 2004 Effects of an Intense Prescribed Forest Fire: Is it Ecological Restoration? *Restoration Ecology* Vol 12 (2): 220-230. June

Gatewood, R. Environmental Assessment for Management Ignited Prescribed Fires for 2002-2003. Big Bend National Park. Park files.

Gomez, A.R. 1991. *A Most Singular Country. A History of Occupation in the Big Bend*. NPS Department of the Interior, Santa Fe, NM. A Charles Readd Monograph in Western History No. 18. Brigham Young University. 241p.

Guertin, P. and W. Halvorson. 2004. Survey of buffelgrass (*Pennicetum ciliare*) in Big Bend National Park, Texas. Conducted through USGS Sonoran Desert Field Station.

Hastings, J.R and R.M Turner. 1965. *The Changing Mile: an ecological study of vegetation change in time in the lower mile of an arid and semiarid region.* Tucson: Univeristy of Arizona Press.

Havstad, K.M. An Overview of Arid Grasslands in the Chihuahuan Desert. In symposium proceedings, The Future of Arid Grasslands: Identifying Issues, Seeking Solutions. Tucson, Arizona, October 13-16, 1996. USDA/USFS. Rocky Mountain Reearch Station, Ft. Collins, CO. RMRS-P-3

Howard, W.E., R.L. Fenner, and H.E. Childs, Jr. 1959. Wildlife survival in brush burns. *Journal of Range Management.* 12:230-234

Huff, M.H. and J.K. Smith. Fire Effects on Animal Communites. In *Wildland Fire in Ecosystems. Effects of Fire on Fauna*. 2000. USDA/USFS. Rocky Mountain Research Station. General Technical Report RMRS-GRT-42-Volume 1. pp 35-42.

Humfrey, R.J. Fire in the Deserts and Desert Grasslands of North America. In Fire and Ecosystems (T.T. Kozlowski and C.E. Ahlgren) San Francisco: Academic Press 1974. pp. 365-399.

Jones, A. T. 2000. Bibliography of Fire Effects on Cultural Resources. Western Region Archeological Conservation Center, National Park Service, Tucson, Arizona.

Kaib, M., C.H. Baisan and T.W. Swetnam. Historical Patterns of Surface Fire in Canyon Pine-Oak Forests, Savannas, and Intervening Semiarid Grasslands of the Southwest Borderlands: An Abstract of Work in Progress. In symposium proceedings, The Future of Arid Grasslands: Identifying Issues, Seeking Solutions. Tucson, Arizona, October 13-16, 1996. USDA/USFS. Rocky Mountain Reearch Station, Ft. Collins, CO. RMRS-P-3

Kaufmann, M.R., L.S. Huckaby, C.M. Regan and J. Popp. Forest Reference Conditions for Ecosystem Manaagement in the Sacramento Mountains, New Mexico. USDA Forest Service General Technical Report. RMRS-GTR-19. September 1998, 87p.

Kittams, W. H. 1972. Effect of fire on vegetation of the Chihuahuan Desert region. P. 427–444 in Proceedings Annual Tall Timbers Fire Ecology Conference, June 8–9, 1972.

Langford, J.O. and F. Gipson. 1952. *Big Bend. A Homesteader's Story*. Austin, TX: University of Texas.

Lair, K and S. Wynn. 2002. *Revegetation Strategies and Technology Development for Restoration of Xeric Tamarix Infestation Sites Following Fire*. U.S. Dept. Of the Interior, Bureau of Reclamation, Technical Service Center, Denver, CO. Technical Memorandum No. 8220-02-06.

Leopold, Aldo, S., S. A Cain, C. M. Cottam, I. N. Gabrielson and T. L. Kimball. 1963. Wildlife management in the National Parks. In Administrative Policies of the National Park Service. Washington, D.C.

Lyon, L.J, E. S. Telfer, and D.S. Schreiner. Direct Effects of Fire and Animal Responses. In *Wildland Fire in Ecosystems. Effects of Fire on Fauna.* 2000. USDA/USFS. Rocky Mountain Research Station. General Technical Report RMRS-GRT-42-Volume 1. pp 17-23.

Lyon, L.J, M.H. Huff, E.S. Telfer, D.S. Schreiner, and J.K. Smith. Fire Effects on Animal Populations. In *Wildland Fire in Ecosystems. Effects of Fire on Fauna*. 2000. USDA/USFS. Rocky Mountain Research Station. General Technical Report RMRS-GRT-42-Volume 1. pp 25-34.

Maresh, J. Spring 2003. Survey of Black-capped Vireo, Big Bend National Park, Brewster County, Texas. Report to the National Park Service.

Maya, Y. and L. Arriga. 1996. Litter and phonological patterns of the dominant overstory species of a desert scrub community in northwestern Mexico. *Journal of Arid Environments* 34: 23-35.

McDougal, William B., W. P. Taylor and W. B. Davis. 1944. Memorandum, June 13,1945 on a Preliminary Report of an Ecological Survey of Big Bend National Park. On file: Office of Science and Resource Management and Natural History Library. Big Bend NP.

McKernan, P. 2003. The Effect of Fire on Grass and Shrub Cover in Big Bend National Park, Texas. MS Thesis, Department of Biology, Baylor University, Waco, Texas.

Maxwell, R.A. 1994. *The Big Bend of the Rio Grande. A Guide to the Rocks, Landscape, Geologic History, and Settlers of the Area of Big Bend National Park.* Bureau of Economic Geography, University of Texas. 138 p.

McPherson, Guy, R. 1995. The role of fire in desert grasslands. In *The Desert Grasslands*. M. P. Mclaren and T. R. Van Devender (eds). Tucson, AZ: University of Arizona Press.

Moir, W. H. 1982. A Fire History of the High Chisos, Big Bend National Park, Texas. *Southwestern Naturalist* 27: 87-90.

Muldavin, E., S. Wondzell and J. Ludwig. 2001. Forty Years of Vegetation Change in Desert Grasslands of the Big Bend National Park. Big Bend NP files.

Nabi, A.A. 1978. Variation in successional status of pinyon-juniper woodlands of the Great Basin. Logan, Utah: Utah State University. Thesis 126p.

NPS Director's Order #12. 2001. Conservation Planning, Environmental Impact Analysis, and Decision Making. Washington D. C.: U.S. Department of Interior.

NPS. 2001. Exotic Plant Management Team Annual Report. Biological Resource Management Division.

NPS Director's Order #18. 1998. Wildland Fire Management.

NPS 2002. Wildland Fire Management Reference Manual 18. Version 3. November 5, 2002.

NPS. 2003. Fire Monitoring Handbook. Boise (ID): Fire Management Program Center, National Interagency Fire Center. 274 p.

Newman, D. 1993. Element stewardship abstract for *Sorghum halepense*. The Nature Conservancy. http://tncweeds.ucdavis.edu/esadocs/documnts/sorghal.rtf

Patton, D.R. 1992. *Wildlife Habitat Relationships in Forested Ecosystems*. Portland, OR: Timber Press Inc. p. 392.

Paysen, T. E., R. J. Ansley, J. K. Brown, G. J. Gottfried, S. M. Haase, M. G. Harrington, M. G. Narog, S. S. Sackett, and R. C. Wilson. 2000. Fire in western shrubland, woodland, and grassland ecosystems. P. 121–159 in J. K. Brown and J. K. Smith, editors. Wildland Fire in Ecosystems: Effects of Fire on Flora. Gen. Tech. Rep. RMRS-GTR-42-vol. 2. USDA Forest Service, Rocky Mountain Research Station, Ogden, Utah. 257 p.

Powell, A. M. *Trees and Shrubs of the Trans-Pecos and Adjacent Areas*. 1998. Austin: The University of Texas Press

Richter, B.S., and J.C. Stultz. 2002. Mychorrhizal innoculation of big sacaton: Implications for grassland restoration of abandoned agricultural fields. *Restoration Ecology* 10(4):607-616

Robbins, L.E., and R.L. Myers. 1992. Seasonal effects of prescribed burning in Florida: a review. Misc. Pub. No. 8. Tall Timbers Trsearch, Inc., Tallahassee, FL. 96 p.

Sandberg, D. V., R. D. Ottmar, J. L. Peterson, and J. Core. 2002. Wildland fire on ecosystems: effects of fire on air. Gen. Tech. Rep. RMRS-GTR-42-vol. 5. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT.

Schmalzel, R., E.T. Anderson, K. Rice, and P. Quirk. 1999. Study of the Bunched Cory Cactus (*Coryphantha ramillosa* Cutak). Final Report Conducted by the Desert Botanical Garden, Phoenix under FWS Agreement No: 1448-00002-96-0854. 59 p.

Scifres, Charles, J. and Wayne T. Hamilton.1993. *Prescribed Burning for Brushland Management. The South Texas Example*. College Station: Texas A & M University Press. 245 p.

Schmidley, D. J. 2002. Te*xas Natural History. A Century of Change*. Lubbock, TX: Texas University Press. p. 534.

Schmidt, R.H. 1986. Chihuahuan Climate. Pp.40-63. In *Second Symposium on Resources of the Chihuahuan Desert Region, United States and Mexico.* J.C. Barlow, A.M. Powell, and B.N. Timmermann, Chihuahuan Desert Institute, Alpine, Texas.

Scurlock, D. From the Rio to the Sierra: An Environmental History of the Middle Rio Grande Basin. USDA Forest Service General Technical Report. RMRS-GTR-5. May 1998.

Sexton, T., and J. Boone. 1999. Review of Big Bend Prescribed Fire Program. BBNP files.

Sirotnak, J. 1998. Report on Exotic Plants in Big Bend National Park. Internal Report. Big Bend National Park files.

Singer, F.J., W. Schreier, J. Oppenheim, and E.O. Garton. 1989. Drought, fires and large mammals. *Bioscience* 39:716-722.

Sprugel, Daniel. 1991. Disturbance, Equilibrium, and Environmental Variability: What is ‘Natural’ Vegetation in a Changing Environment? *Biological Conservation* 58(1991) 1-18.

Swetnam, T.W. 1990. Fire history and climate in the southwestern United States. Krammes, J.S., tech. Coordinator. Proceedings of the symposium, Effects of fire management of Southwestern natural resources. 1988, Nov 17-18, Tucson, AZ. USDA Forest Service GTR-RM-191.

Swetnam, T.W., and C. H. Baisan. 1996.Histoical fire regimes in the southwestern United States since AD 1700.In Allen, C.D. (ed) Fire effects in southwestern forests:proceedings of the second La Mesa fire symposium; 1994 March 29-31; Los Alamos NM. General Technical Report RM-GTR-286. Fort Collins, CO: US Department of Agriculture, Forest Service. Rocky Mountain Forest and Range Experiment Station: 11-32.

The Fire Behavior Field Reference Guide. Feb 1992. Publication of the National Wildfire Coordinating Group: National Interagency Fire Center, Boise Idaho. Govt. Publication No. PMS436-4

Trabaud, L. (ed). 1987. *The Role of Fire in Ecological Systems*. The Hague, Netherlands: SPB Academic Publishing. 157 p.

Tu, M. 2002. Element stewardship abstract for *Cenchrus ciliarus* L. The Nature Conservancy. (http://tncweeds.uncdavis.edu/esadocs/documnts/cenccil.pdf.)

Tyler, R. 1975. *The Big Bend. A History of the Last Texas Frontier*. Washington, D.C: NPS Department of the Interior.

NPS. 2003. Fire Monitoring Handbook. Boise (ID): Fire Management Program Center, National Interagency Fire Center. 274 p.

U.S. Forest Service Fire Effects. Site Accessed 12-14 October, 2003 and 23-30 March, 2004. Web Site. http://www.fs.fed.us/database/feis/plants/graminoid/arudon/botanical_and_ecological_characteristics.html

Van Devender, T.R. 1986. Pleistocene climates and endemism in the Chihuahuan Desert flora. pp.1-19. In *Second Symposium on Resources of the Chihuahuan Desert Region, United States and Mexico.* J.C. Barlow, A.M. Powell, and B.N. Timmermann, Chihuahuan Desert Institute, Alpine, Texas.

Van Devender, T.R. 1990. Late Quaternary Vegetation and Climate of the Chihuahuan Desert, United States and Mexico. Pp.104-133. In *Packrat Middens: The Last 40,000 Yeears of Biotic Change*. J.L. Betancourt, T.R. Van Devender, and P.S. Martin, (eds). Tucson, AZ: University of Arizona Press.

Van Devender, T.R and T.L. Burgess. 1985. Late Pleistocene woodlands in the Bolson de Mapimi: A refugium for the Chihuahuan Desert biota? *Quaternary Research* 24:340-353.

Van Devender, T.R. and W.G. Spalding. 1979. Development of vegetation and climate in the Southwestern United States. *Science* 204:701-710.

Wauer, R. and D. Riskind (eds). 1974. *Transactions of the Symposium on the Biological Resources of the Chihuahuan Desert Region. United States and Mexico*. Sul Ross State University, Alpine, TX. U.S. Department of the Interior. NPS Transactions and Proceedings Series. Number three, 1977.

Wauver, R. and J. D. Ligon. Distributional Relations of Breeding Avifauna of Four Southwestern Mountain Ranges. In *Transactions of the Symposium on the Biological Resources of the Chihuahuan Desert Region.United States and Mexico*. Sul Ross State University, Alpine, TX. U.S. Department of the Interior. NPS Transactions and Proceedings Series. Number three, 1977. pp. 567-578.

Wells, P. and V. Post. Glacial Origins of the Present Chihuahuan Desert Less than 11,500 Years Ago. In *Transactions of the Symposium on the Biological Resources of the Chihuahuan Desert Region. United States and Mexico*. Sul Ross State University, Alpine, TX. U.S. Department of the Interior. NPS Transactions and Proceedings Series. Number three, 1977. pp. 67-84.

Welsh, M. 2002. *Landscape of Ghosts – River of* Dreams. An Administrative History of Big Bend National Park. Boulder: University of Colorado Press.

Whelan, R.J. 1995. *The Ecology of Fire*. Cambridge, England: Cambridge University Press.

Wildand Fire in Ecosystems. Effects of Fire on Flora. 2000. USFS. Rocky Mountain Research Station. General Technical Report RMRS-GTR-42 volume 2.

Wondzell, S.M., G.L. 1996. Cunningham and D. Bachelet. Relationships between landforms, geomorphic processes and plant communities on a watershed in northern Chihuahuan Desert. *Landscape Ecology* 11 (6): 351-362

Wright, H.A and A. W. Bailey. 1982. Fire Ecology in United States and Southern Canada. New York: John Wiley & Sons. 501p.

Appendix A: Full list of issues related to fire management planning at Big Bend National Park.

Identified from the Intermountain Regional Office Environmental Screening Form (IMRO ESF). Meeting held at Big Bend NP December 11-12, 2002.

Impact Area	Topics from ESF	Issues, Concerns, Opportunities
Human Experience & Interaction	**Visitor Experience**	
	safety	• Fire can put visitors, staff and firefighters at risk • The use of fire can reduce hazard fuels • Evacuations could adversely affect visitor experience and be costly • Hikers and campers in wilderness are at risk • A single road into and out of the Chisos Basin could cause evacuation problems
	air quality	• This class I airshed allows broad day time views • Smoke obscures views
	night skies	• Crystal clear views are obscured but smoke creates great sunsets
	mechanical sounds	• Equipment used during suppression is noisy (chainsaws, helicopters, vehicles and generators)
	views	• Cherished views may become charred • Fire may enhance and reveal new vistas
	visitation interpretation	• Some visitors may seek alternate destinations • Fire operations and sites provide interpretative opportunities
	recreational opportunities	• Trails, vistas, campgrounds, and roads may be temporarily closed
	Land Use	
	property damage	• Structures, signage and landscaping are at risk
	neighbors	• Fire may cross boundaries- private, state and international • Ranch inholdings may lose grazing, fences, and livestock • Loss of telephone and utility poles may lead to litigation against the park • Hunters camping on inholdings may start illegal campfires
	local economy	• Tourism may decline after a well-publicized fire resulting in loss of income to local merchants and the park
Natural Resources	**Vegetation**	
	composition	• Fire intolerant species suffer • Fire-tolerant species benefit from decreased competition such as mid-elevation grasses • Diversity can increase after fire • Diversity can decrease with fires in fire-adapted exotics
	structure	• Intense fires can eliminate entire stands of vegetation
	unique stands	• Fire may damage or eliminate unique stands of vegetation where there are no colonizing seed sources
	non-indigenous species	• Fire facilitates invasion by exotic fire-tolerant buffelgrass, Bermuda grass, Johnson grass, saltcedar, Russian thistle, Lehmann’s lovegrass and giantreed.
	Species of Special Concern	
	plants	• Rare, protected, or listed plants may suffer injury, death, or destruction of habitat by fire • Fire adapted species benefit from reduced competition • Nutrient ash may be beneficial to seedlings
	animals	• Rare, protected, or listed animals may suffer injury, death, or destruction of habitat by fire

Impact Area	Topics from ESF	Issues, Concerns, Opportunities
		• The effects of fire on the habitat of many species is unknown • Fire creates edge habitat preferred by some species • Fire can increase browse and forage for deer • Fish and mussels could be affected by petroleum leaking into creeks from trucks and igniters used in fire management activities • Reducing brush around springs can increase subsurface flows benefiting amphibians and fish • Reducing brush can also increase trampling around springs and raise water temperatures
	Important Wildlife Considerations	
	key species	• Fire may kill, injure, or displace species that visitors want to see such as black bear, mountain lion and Colima warblers
	fire timing	• Fires during breeding seasons can disrupt nesting and maturation of species • Species adapted to cyclical fire will recover provided that there are sufficient populations for recolonizing and enough remaining habitat
	Unique Sites	
	ecoregions	• The Chisos Mountains and Pine Canyon are unique in the US and perhaps the US-Mexico region containing relic populations of aspen and Arizona Cypress, and many endemic species
	education	• Opportunities exist to use these special areas to illustrate the importance of the Biosphere designation
	natural sites	• Meadows, grasslands, savannahs, dunes, springs, limestone habitat, woodlands and forest
	Wilderness	
	ecology	• Allowing fire maintains natural succession processes
	visitor experience	• Presence and effects of fire help maintain the integrity of wilderness
	fire operations	• Evacuations from wilderness can be challenging • Fire operations may attract people to closed areas hampering operations • Restrictions on suppression techniques in wilderness can determine the course of fire
	Geological Resources	
	soils	• Fire can negatively impact soils by reducing infiltration, initiating erosion, silting waterways and roads, and transporting weed seed
	education	• Exposed vistas and features offer opportunities for interpretation and education
	visual quality	• Exfoliation and blackening (spalling) creates stark visual impacts
	Geohazards/mudflows	• Potential for increased runoff and erosion when rain hits bare soils • Potential for flooding increases with storms following fires • Creek drainages and other aquatic habitats vulnerable from silt and debris

Impact Area	Topics from ESF	Issues, Concerns, Opportunities
	Water	
	quantity	• Less vegetation after fire results in greater runoff
	quality	• Runoff from slopes will contain increased particulate load; may change pH of streams affecting aquatic life
	Floodplains/wetlands	
	hydrology	• Excessive sediment loads in Rio Grande may affect relationships with downstream users • Waters may become polluted with petroleum from suppression activities • Water taken for suppression may decrease availability in already low areas
	vegetation	• Knocking back thickets near streams can increase flows benefiting wildlife • Removal of tamarisk can lead to a rise in the watertable • Sites may become drier following fire • Vegetation may be trampled during suppression
	wildlife	• Some springs may be more heavily used when fire removes the surrounding vegetation
Cultural Resources	**Cultural Resources**	
	archeological sites	• Suppression activities can directly damage site features and contribute to loss of significant archeological context • Fires can expose sites to vandalism • Fires cause loss of vegetative cover which open sites to erosion • Only 3% of the park is surveyed and damage could occur inadvertently
	structures	• Timbers, glass, metals and ceramics can be destroyed by fire in historic structures • Historic artifacts on the surface and in trash dumps are important for interpreting use of the site and can be adversely damaged by fire and suppression activities
	cultural landscapes	• Cultural sites are not well documented; losses could be permanent or recoverable only after long periods • The vegetative component of a landscape may be a significant character defining resource to preserve instead of burn
Federal and State Policies	**Agency Policies**	
	U.S. Fish & Wildlife Service	• The park works with the USFWS on protection of threatened and endangered species
	Texas SHPO	• The park works with the Texas State Historic Preservation Office on protection of cultural resources
	Mexico	• Existing agreements of cooperation exist; Los Diablos fight fires in the US. New agreements are being developed
	Texas Parks & Wildlife	• Agreements are being developed to work with several species of concern, and on fire along the border of the Blackgap Wildlife Management Area
	Tribal Affiliates	• Agreements will be developed as needed
	Neighbors	• Formal agreements are being developed on an on-going basis to accommodate more cost-effective and ecologically sound suppression policies along park boundaries

Appendix B. Fire Effects on Dominant Plant Species in Big Bend National Park

Table B-1.Floodplain and Upland Riparian: Fire Ecology of Main Species. FEIS is the Fire Effects Information System maintained by the USDA Forest Service that contains literature reviews: http://www.fs.fed.us/database/feis/.

Species	Fire Ecology/Adaptations	Source
Baccharus halimifolia	Shrubby groundseltree is killed by fire and recolonization probably requires windborn seed sources.	FEIS
Chilopsis linearis	Desert willow can be top-killed by fire but resprouts from the root crown becoming multi-stemmed.	FEIS
Muhlenbergia rigens	Deer muhly is not included in the fire literature. Other grass species show variable response depending on fire season, top growth and post-fire conditions. Dense basal cover may protect growing points on a low-intensity fire; high fuels and intensity may lead to plant death. Reestablishment is probably by seed.	FEIS
Populus fremontii	Cottonwoods are easily killed by fire and resprouting from root crown is diminished after 25 years. Can reestablish be seed in absence of competitive vegetation.	FEIS
Prosopis glandulosa	Honey mesquite resprouts readily following topkill from buds on extensive underground root systems.	FEIS
Prosopis pubescens	Screwbean is more easily top-killed or killed by fire than other mesquites. Resprouts weakly; easily outcompeted by saltcedar.	FEIS
Sporobolus airoides	No literature on Alkali sacaton but other species respond after fire depending on amount of root crown loss, season of burn and post-fire precipitation.	FEIS
Exotic species		
Arundo donax	Giantreed is highly flammable year round; top-killed by fire but resprouts vigorously from rhizomes and overtakes native vegetation.	FEIS
Cynodon dactylon	Above ground stems are consumed by fire but Bermuda grass responds vigorously from rhizomes if moisture is available.	FEIS
Pennisetum ciliare	Buffelgrass is a warm-season perennial that resprouts following fire and also reestablishes by seed stored in soil. It may increase cover following fire.	
Tamarix ramossisima	Saltcedar can resprout from root crowns and stem pieces; buildup of fuels within plant increases flammability; post-fire response can lead to dense thickets.	FEIS

Table B-2. Desert Scrub: Fire Ecology of Main Species. FEIS is the Fire Effects Information System maintained by the USDA Forest Service that contains literature reviews: http://www.fs.fed.us/database/feis/.

Species	Fire Ecology/Adaptations	Source
Agave lechuguilla	Lechuguilla occurs in dense stands that can readily carry hot fire; mortality tends to be high; some plants survive and produce offsets; plants can escape fire by living in rocky microhabitats.	FEIS
Bouteloua curtipendula	Sideoats grama response to fire depends on growth form, climatic conditions, season of burn, and severity of fire; reestablishment occurs through seed and/or rhizomes; recovery time is variable, but 2 to 3 years may be required.	FEIS
Flourensia cenua	Little is known about the effects of fire onTarbush. Fire is not expected to kill except if buildup of understory fuels.	FEIS
Fouquieria splendens	Ocotillo is easily damaged by fire; less in the dormant season; can resprout from root crown after low-intensity fire; occurs where fire is unlikely except after wet years and buildup of grasses.	FEIS
Hechtia texensis	Texas falseagave or Hetchia	
Larrea tridentata	Creosote's resinous leaves are very flammable but sparse grasses and patchy fires mean few creosote burn. They resprout weakly.	FEIS
Opuntia spp.	Prickly pear is consumed by hot fire. Surviving pads that connect with the ground may reestablish.	McPherson 1995
Parthenium incanum	Mariola – resprouting effects unknown	
Yucca spp.	Yucca increases in the absence of fire. Can resprout from buds under the stem depending on fire severity.	FEIS
Hilaria mutica	Tobosagrass response to fire depends on season of burn, soil moisture and post-fire precipitation regimes; recovery appears to take several years. Underground rhizomes send out new shoots. Slow burning hot fires can be very damaging.	FEIS Humphrey 1974
Exotics		
Pennisetum ciliare	Buffelgrass is top killed by fire and reestablishes from seed stored in soil.	FEIS
Eragrostis lehmanniana	Lehmanns lovegrass survives fires by sending new shoots from underground stems or from seed. Severe fire kills most plants but rains following fire can lead to rapid reestablishment.	

Table B-3. High Desert Grasslands: Fire Ecology of Main Species. FEIS is the Fire Effects Information System maintained by the USDA Forest Service that contains literature reviews: http://www.fs.fed.us/database/feis/.

Species	Fire Ecology/Adaptations	Source
Acacia constricta	Catclaw acacia can resprout from the root crown following top-kill. Severe fires will destroy underground roots.	FEIS
Agave lechuguilla	Lechuguilla burns hotly and suffers high mortality. Surviving rosettes and blades reestablish after several years.	FEIS
Aristida spp.	Three-awns suffer damage from fire with growing points close to the soil surface. A 1975 fire in November in Big Bend led to 650% increase in forb and succulent cover over grasses.	FEIS
Bouteloua breviseta	There wa no literature for Chino grama	
Bouteloua eriopoda	Black grama has the reputation of being fire-sensitive, recovering slowly after fire through vegetative growth; healthy stands recover more readily, given decent moisture; carries fire if cover dense and conditions windy.	FEIS
Bouteloua gracilis	Blue grama is topkilled by fire, but fire generally increases occurrence, production, and cover; seed and seedstalk production may also be stimulated by fire; wet years post-fire increase yield.	FEIS
Bouteloua hirsuta	Hairy grama cover was positively correlated with fire frequency in Minnesota; most studies conclude it is undamaged by fire following a season or two of depressed production.	FEIS
Dalea spp.	Dalea spp.	
Dasylirion wheeleri	Young sotol are easily killed; mature sotol with trunks sheathed in dead leaves makes them especially susceptible to fire; stalks attract lightning; plant tops spread fire by falling off and rolling downhill; plants occasionally resprout if lightly or moderately burned.	FEIS
Digitaria californica	Recovery of California cottontop depends on post-fire moisture; wet summers can lead to full recovery; growing points are protected underground.	FEIS
Lepochloa dubia	Green sprangletop	
Leucophyllum minus	Ceniza	
Nolina microcarpa	Bear-grass or Sacahuista resprouts from the woody, underground caudex after fire; cool fires result in little or no mortality; hot fires kill many young plants and some mature plants.	FEIS
Opuntia spp.	Prickly pear is susceptible to fire but rarely are all plants or parts burned. Resprouting from the root crown or from layering of surviving pads. Increased	FEIS

	fire frequency is thought to increase mortality.	
Pleuraphis mutica	Tobosagrass	
Sporobolus airoides	No literature on Alkali sacaton but other species respond after fire depending on amount of root crown loss, season of burn and post-fire precipitation.	FEIS
Viguiera stenoloba	Skeletonleaf goldeneye is highly flamable.	
Yucca torreyi	Yucca flowerstalks act as lightning receivers ; mature dead skirts of leaves are consumed by fire and may spread fire as the plant rolls downhill.	FEIS

Table B-4. Shrub Woodlands: Fire Ecology of Main Species. FEIS is the Fire Effects Information System maintained by the USDA Forest Service that contains literature reviews: http://www.fs.fed.us/database/feis/.

Species	**Fire Ecology/Adaptations**	**Source**
Aloysia gratissima	Bee bush is not known to be easy to ignite or burn	Staff observation Big Bend.
Acacia constricta	Catclaw acacia can resprout from root crowns provide the fire is not severe.	FEIS
Juniperus pinchotti	Mature redberry or Pinchot juniper resists fire; will resprout following topkill if the basal bud is protected by soil; prescribed fire kills seedlings and saplings. Extreme conditions needed to kill mature trees.	FEIS
Juniperus deppeana	Alligator juniper canopies are often high enough so that fires scorch but do not severely damage the crown. Bark also provides protection from fire. It is generally capable of prolific sprouting after aboveground vegetation is consumed by fire, particularly if the resprouting zone is covered by soil.	FEIS
Quercus grisea	No information in the literature on Gray oak. Most oaks survive low-intensity, fast-moving fire. Fires in closed canopy oak forests probably lead to stand replacement.	FEIS
Quercus emoryi	Emory oak resprouts vigorously from root crown or stump following fire; fire probably occurred every 10-20 years where lower elevation grasslands led into Madrean oak-pine woodlands.	FEIS
Rhus virens	There was no information on fire effects in the literature for Evergreen sumac. Other sumacs are top-killed by fire but resprout from root crowns and reestablish by seed. Some species increase following fire.	FEIS
Vauquelinia corymbosa subsp. *angustifolia*	Slimleaf vauquilinia	

Table B-5. Grassy Woodlands: Fire Ecology of Main Species. FEIS is the Fire Effects Information System maintained by the USDA Forest Service that contains literature reviews: http://www.fs.fed.us/database/feis/.

Species	Fire Ecology/Adaptations	Source
Achnatherum hymenoides	Pinyon rice grass is relatively open limiting damage to below ground parts; usually top-killed by fire and reestablishes by seed. Not intensively researched	FEIS.
Agave harvardiana	Mature Harvard agave may take several years to die following fire. Young rosettes under the skirt of an adult are usually consumed by fire.	Howard 1996; Johnson 2001
Garrya wrightii	Wright silktassel resprouts from the root crown following fire. Most information comes from chapparal in Arizona.	FEIS
Juniperus deppeana	Alligator juniper canopies are often high enough so that fires scorch but do not severely damage the crown. Bark also provides protection from fire. It is generally capable of prolific sprouting after aboveground vegetation is consumed by fire, particularly if the resprouting zone is covered by soil.	FEIS
Juniperus flaccida	Specific information about fire effects is lacking; shedding bark and volatile leaf oils probably make it very flammable and easily killed. Patchy burns would allow it to survive in refugia.	FEIS
Juniperus pinchotti	Mature redberry or Pinchot juniper resists fire; will resprout following topkill if the basal bud is protected by soil; prescribed fire kills seedlings and saplings. Extreme conditions needed to kill mature trees.	FEIS
Muhlenbergia emersleyi	Low fire intensity can be survived but intense fire usually kills; reestablishment is by seed	FEIS
Pinus cembroides	Fire effects on Mexican pinyon depend on stand density and understory species and fuel levels. Mature 80 year old trees with grassy understory are fire resistant, young trees in dense stands are easily killed.	FEIS
Quercus grisea	No information in the literature on Gray oak. Most oaks survive low-intensity, fast-moving fire. Fires in closed canopy oak forests probably lead to stand replacement.	FEIS
Quercus emoryi	Emory oak resprouts vigorously from root crown or stump following fire; fire probably occurred every 10-20 years where lower elevation grasslands led into Madrean oak-pine woodlands.	FEIS
Quercus gravesii	There is no literature on Graves oak but most oaks can resprout from the root crown following fire.	

Table B-6. Forest: Fire Ecology of Species. FEIS is the Fire Effects Information System maintained by the USDA Forest Service that contains literature reviews: http://www.fs.fed.us/database/feis/.

Species	Fire Ecology/Adaptations	Source
Dominant		
Juniperus deppeana	Alligator juniper canopies are often high enough so that fires scorch but do not severely damage the crown. Bark also provides protection from fire. It is generally capable of prolific sprouting after aboveground vegetation is consumed by fire, particularly if the resprouting zone is covered by soil.	FEIS
Juniperus flaccida	Specific information about fire effects is lacking; shedding bark and volatile leaf oils probably make it very flammable and easily killed. Patchy burns would allow it to survive in refugia.	FEIS
Juniperus pinchotti	Mature redberry or Pinchot juniper resists fire; will resprout following topkill if the basal bud is protected by soil; prescribed fire at 10-20 year intervals kills seedlings and saplings. Extreme conditions needed to kill mature trees.	FEIS
Pinus cembroides	Fire effects on Mexican pinyon depend on stand density and understory species and fuel levels. Mature 80 year old trees with grassy understory are fire resistant, young trees in dense stands are easily killed.	FEIS Moir (1982)
Quercus gravesii	Graves oak	
Subdominant to rare		
Acer grandidentatum	Bigtooth maple live in moist sites , produce shady crowns that suppress understory and tend to burn infrequently; following crown destruction by fire, some resprout from root crown, but not vigorously.	FEIS
Arbutus xalapensis[texana]	Observation of fire scars on Texas madrone suggest some survival after fire; moist habitats generally protect from fire; post-fire sprouting is not documented but not ruled out; bird-dispersed seed may establish on burns.	FEIS: Staff observation Guadalupe Mountains NP
Cupressus arizonica	Arizona cypress less than 4” in diameter is killed by fire; relict populations probably survived patchy fast-moving grass fires; fire stimulates seed release.	FEIS
Ostrya chisosensis	Information on Chisos hophornbeam not available . Other hophornbeam species believed to be killed by fire; occur in juniper-pinyon communities that burned every 10-30 years	FEIS
Pinus ponderosa	Interior ponderosa pine can survive considerable scorching. Fire adaptations include: open crowns; self-pruning branches; thick, insulative, relatively unflammable bark; thick bud scales; tight needle	FEIS

	bunches that open into a loose arrangement that does not favor combustion; high foliar moisture; and a deep rooting habit.	
Populus tremuloides	Much work on quaking aspen comes from the northern Rockies and eastern U.S.; the species is topkilled by fire, but sends up a "profusion" of stems for several years post-fire; new stands can develop within a decade; fire-scarred aspens in Utah showed 7- to 10-year fire frequency pre-1885; lack of young stands in the west may be due to absence of fire.	FEIS
Pseudotsuga menziesii	Mature Rocky Mountain Douglas-fir is generally more fire resistant than spruces and true firs and equally or slightly less fire resistant than ponderosa pine. Mature trees can survive moderately severe ground fires because thick, corky bark insulates the cambium from heat damage. Where fire is frequent young trees are killed.	FEIS
Quercus rubra	Mature red oak can survive fires with up to 66% bark burn but are more susceptible than other oak species; trees may resprout from the root crown. Mortality increases with fire severity.	FEIS
Quercus rugosa	Netleaf oak. No literature on this species; severity of fire and protection of root crown determine resprouting in many oak species.	

Appendix C. Cultural Resource Matrix

This matrix was completed by Tom Alex and reviewed as part of the Cultural Resource Component (the document that summarizes all cultural resource concerns under the FMP) by W. Andy Cloud at Sul Ross State University at Alpine. The Texas State Historical Preservation Office reviewed the CRC.

The 6-page matrix considers historical, archeological, architectural, engineering, and cultural values to identify resources sensitive to fire program activities. It also specifies the particular aspects of the resource at risk, reviews what fire program activities create the risk, defines protection objectives for these resources, and suggests methods to minimize or mitigate impacts in order to achieve these objectives. An initial itemized list of treatment by site has been developed to guide operations under the new FMP.

Definition of terms:

Historic contexts are the historic and prehistoric themes under which various resources were created and used. Individual resources are best understood and evaluated by understanding the roles they played within specific historical periods. For example the various eras of the Prehistoric American Indian Period are characterized by changes in specialized hunting tools. Military forts or presidios, mining, and ranches characterize the Mexicans and Anglos Historic Period. The park period features superb rock construction by the Civilian Conservation Corps.

Resource types represent general function or morphology such as historic districts or cultural landscapes. They include stone hunting tools from prehistoric times, the remains of mines, farming systems and military establishments, and some resources more difficult to date such as lithic scatters.

Elements are the specific physical characteristics of resource types. Identifying the elements allows us to define specific elements or values at risk from various fire management activities. Historical buildings may contain burnable wooden timbers, glass that may melt, or ceramics that may crack under high temperatures. Retardant or water may crack or shatter rocks heated by fire within an archeological site.

Risk conditions or activities are the specific environmental conditions and/or fire management activities that place particular resources at risk. Growth of brush around historic sites increases the temperature of fire; the presence of burnable timbers, glass, metals and ceramics creates risks best mitigated by removal of nearby flammable materials.

Fire management objectives guide actions in a way that protects the elements or values at risk. The CRC recommends a variety of approaches for reducing risk from fire depending on the site and its components.

Treatments or prescriptions are methods of attaining the objectives for cultural resources. The park has prepared a preliminary list of sites and proposed treatments for consideration under the fire program. Treatments include:

- Reducing fuels in and around sites through manual or mechanical thinning, prescribed fire or natural ignitions depending on site.
- Manage nearby fire to ensure that sensitive resources are not affected by fire containment or suppression activities.
- Prior identification of vehicle access and fire breaks around sites with high public visitation.
- Undertaking cultural resource inventories designed by qualified cultural resource specialists in burn units prior to prescribed burn activities.

Seven tribes are affiliated with the park. Apache Tribes of Oklahoma, Blackfeet, Comanche Tribe of Oklahoma, Kickapoo Traditional Tribe of Texas, Kiowa Tribe of Oklahoma, Mescalero Apache Tribe, and Ysleta Del Sur Pueblo. Also consulted are relevant state and federal agencies, local governments, local businesses, and private residents living along the boundary or nearby the park.

The park sent out public scoping newsletters in June 2003 and held open house meetings in Alpine and Study Butte, Texas. The comment period extended to the end of August 2003. Tribes were not informed within the original comment period because of confusion about which tribes were affiliated with the park. Research by staff in Santa Fe NPS and the park Tribal Liaison Officer, expanded the original list from 3 to 5 and then to 7 tribes. Each tribe will receive a copy of the draft EA when completed and invited to comment on the alternatives.

Big Bend National Park Cultural Resources at Risk from Fire

Historic Context	Resource Type	Elements	Elements or Values at Risk	Risk Conditions	Management Objectives	Treatment or Prescriptions
INDIGENOUS AMERICAN POPULATIONS: Prehistoric Archeology: Prehistoric Use of Natural Stone Sources and Regional Trade	Lithic source, quarried	Quarry Alcoves Quarry Pits Lithic concentrations	Extraction and lithic reduction techniques Chronological and functional data Dating/sourcing	Heat spalling of rock surfaces in alcoves from high intensity/ long residence fire; Ground disturbance; Retardant drops; Temperatures >500C	Avoid disturbance	Pretreatment: hand lines/ring firing; Use water where possible to suppress
	Lithic Source, Surface	Lithic concentrations	Chronological and functional data Lithic reduction techniques Dating/sourcing	High intensity/ long residence fire; Ground disturbance; Retardant drops; Temperatures >500 C	Avoid disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress
INDIGENOUS AMERICAN POPULATIONS: Prehistoric Resource Use, Landscape Use and Settlement Patterns 10,000 BC – AD 1550	Open Campsite	Stone-paved/lined hearths Lithic concentrations	Chronological and functional data Feature integrity Dateable contents of hearths Lithic reduction techniques Lithic sourcing	Moderate to high intensity/ long residence fire; Ground disturbance; Chemical retardant drops; Radiocarbon data contamination from vegetation growth contacting features; Temperatures 300-500 C	Avoid ground disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	Sheltered Sites: Boulder Shelter	Petroglyphs Pictographs Midden Lithic concentrations	Morphological and stylistic data Pigment dating Chronological and functional data Lithic reduction technology Subsistence data	Heat spalling of rock surfaces; Vegetation growth contacting features; Smoke blackening; Radiocarbon data contamination; Temperatures >500 C	Avoid ground disturbance Suppression	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	Sheltered Sites: Rock Shelter	Middens Rock art Vegetal artifacts Stone artifacts Storage cysts Lithic caches Burials	Feature integrity Interpretive value Chronological and functional data Morphological and stylistic data Pigment dating	Heat spalling of rock surfaces; Radiocarbon data contamination from vegetation growth contacting features; Smoke blackening Heat alteration of biotic/mineralogic surface coatings Temperatures >50 C	Avoid ground disturbance Suppression	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	Food processing sites	Cooking pits Bedrock mortars & metates Molcajetes & metates Plant/animal processing tools	Chronological and functional data Subsistence data Lithic reduction techniques Hunting/Gathering methodology	Heat alteration of biotic & mineralogic surface coatings; Radiocarbon data contamination from vegetation growth contacting features; Temperatures >50 C	Avoid ground disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation

Big Bend National Park Cultural Resources at Risk from Fire

Historic Context	Resource Type	Elements	Elements or Values at Risk	Risk Conditions	Management Objectives	Treatment or Prescriptions
	Vision quest/ceremonial observation	Mountaintop stone enclosures Hearths Molcajetes and metates	Ceremonialism and spirituality Chronological data Stone alignments and cairns integrity	Moderate to high intensity/residence fire; Radiocarbon data contamination from vegetation growth contacting features; Heat alteration of biotic/mineralogic surface coatings Temperatures >50 C	Avoid ground disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	Medicine Wheel	Stone lines & circles, horizon alignments, stone mounds and cairns Human burials and associated artifacts Artifact caches	Ceremonialism and spirituality Human remains Mortuary practices Commemorative practices Stone alignments and cairns integrity	Foot traffic Fireline construction	Avoid ground disturbance Suppression	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	Burial Sites	Crevice burials: rock mounds and walls Subsurface burials: rock mounds or paved surfaces Pictographs and petroglyphs Associated artifact/burial goods caches	Human remains Mortuary practices Cultural affiliation Morphological and stylistic data Pigment dating Radiocarbon dating	Heat spalling of rock surface Vegetation growth contacting features Heavy ground disturbance Smoke blackening	Avoid ground disturbance Suppression	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
INDIGENOUS AMERICAN POPULATIONS: Post-Archaic and Pre-Contact Developments: Intercultural Relations Between Southern Plains and Northern Mexico	Campsites containing constructed shelter: Stone enclosures; wickiups	Stacked stone walls Boulder metates Interior and exterior cooking hearths Lithic concentrations Artifact caches	Chronological and functional data Feature/structure integrity Cultural affiliation Radiocarbon data contamination	Heat spalling of rock surfaces; Vegetation growth contacting features; Smoke blackening; Radiocarbon data contamination; Temperatures >500 C	Avoid ground disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
INDIGENOUS AMERICAN POPULATIONS: Contact Period - Post AD 1550	Campsites containing constructed shelter: Stone enclosures, wickiups	Stacked stone walls Boulder metates Interior and exterior cooking hearths Lithic concentrations Artifact caches	Chronological and functional data Feature/structure integrity Cultural affiliation Radiocarbon data contamination	Heat spalling of rock surfaces; Vegetation growth contacting features; Smoke blackening; Radiocarbon data contamination; Temperatures >500 C	Avoid ground disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	Rock Art	Red linear pictographs Depictions of horseback riders	Chronological and functional data Morphological and stylistic data Cultural affiliation Interpretive value Pigment dating	Heat spalling of rock surface Vegetation growth contacting features Smoke blackening Heat alteration of biotic/mineralogic surface coatings	Suppression	Manual fuel reduction

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Historic Context	Resource Type	Elements	Elements or Values at Risk	Risk Conditions	Management Objectives	Treatment or Prescriptions
	Open Campsites	Stone-lined hearths Burned earth surfaces Metal artifacts Ceramic artifacts	Chronological and functional data Feature integrity Diagnostic artifacts	Foot traffic Fireline construction Moderate to high intensity/residence fire? Ground disturbance Chemical retardant drops Vegetation growth contacting features Radiocarbon data contamination Temperatures >500 C	Avoid ground disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
EUROPEAN/ AMERICAN EXPLORATION AND SETTLEMENT, 1848-1890: The Camel Expeditions by the Topographic Corps of Engineers	Landmarks along the routes of the 1859-1860 expeditions	Comanche Trail Campsites at springs and waterholes Glass and metal artifacts	Chronological and functional data Heat damage to solder seams on metal containers, coatings on military insignia	Temperatures >135 C	Avoid ground disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
POLITICAL AND MILITARY AFFAIRS, 1865-1939	Neville Spring Black/Seminole Indian Scout Outpost	Officers Quarters ruin Enlisted Barracks ruin Blacksmith area with metal artifacts Outlier observation posts	Chronological and functional data Heat damage to solder seams on metal containers, coatings on military insignia	Heat spalling of rock Heat spalling of mortar Temperatures >135 C	Avoid ground disturbance	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	Military outlier lookout posts	Stone enclosures Trash dumps	Chronological and functional data Heat damage to solder seams on metal containers, coatings on military insignia	Temperatures >135 C	Avoid ground disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	La Noria Cavalry Camp	Stone alignments Trash dumps	Chronological and functional data Heat damage to solder seams on metal containers, coatings on military insignia Stone alignments defining parade ground Artifacts in trash dumps and on ground surface	Fireline construction Temperatures >135 C	Avoid ground disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	Glenn Springs Cavalry Camp	Stone alignments/ and foundations Metal artifacts Rifle pits/machine gun emplacements Trash dumps	Chronological and functional data Heat damage to solder seams on metal containers, coatings on military insignia Stone alignments defining parade ground and Gary Owen insignia Artifacts in trash dumps and on ground surface	Foot traffic Fireline construction Temperatures >135 C	Avoid ground disturbance	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation

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Historic Context	Resource Type	Elements	Elements or Values at Risk	Risk Conditions	Management Objectives	Treatment or Prescriptions
	Johnson Ranch Airfield	Runway Building ruins and foundations Trash dumps Cemetery	Chronological and functional data Metal, glass, & ceramic artifacts Wooden grave markers and delineators	Melting of non-ferrous metal, glass, ceramic Temperatures > 232 C	Avoid ground disturbance	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	Camp Santa Helena (Castolon)	Buildings Historic artifact scatters	Chronological and functional data Interpretive value Commercial value (store) Govt. property value (storage) Structural integrity	Temperatures > 232 C	Avoid ground disturbance Suppression	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
WESTWARD EXPANSION OF THE UNITED STATES, 1763-1898: The Cattleman's Empire: Ranches	G-4 Ranch / Gano Ranch Site	Building foundations Trash piles Household objects Fence lines, corrals	Wooden structural elements Glass and ceramic artifacts	Temperatures >135 C	Avoid ground disturbance	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
RANCHING: 1880-1944	Ranching sites: Homer Wilson Blue Creek Line Camp, Sam Nail Ranch, K-Bar Ranch, Buttrill Ranch, Rice Ranch, Other ranches	Stone, adobe, wood frame buildings Building foundations Stone ruins Adobe ruins Wooden framing elements Trash Piles Vegetative plantings Fence lines, corrals Masonry dams Earthen dams and stock ponds Waterlines and windmills Water storage structures Family cemeteries	Interpretive value Structural integrity Wooden structural elements Non-ferrous metal, glass, ceramic artifacts Wooden, glass, ceramic funerary objects	Temperatures > 232 C	Avoid ground disturbance Suppression Avoid loss of physical patterning of corrals, fencelines, etc.	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
AGRICULTURE: Flood Plain Farming: Adaptations of the Spanish Acequia Farming System and Indigenous Farming Methodology	Terlingua Abajo community site	Stone ruins Adobe ruins Wooden framing elements Trash Piles Irrigation structures Earthen berms and diversion structures Brick Kiln Cemetery Church Threshing floor	Interpretive value Structural integrity Wooden structural elements Non-ferrous metal, glass, ceramic artifacts Wooden, glass, ceramic funerary objects	Temperatures >135 C	Avoid ground disturbance	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation

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Historic Context	Resource Type	Elements	Elements or Values at Risk	Risk Conditions	Management Objectives	Treatment or Prescriptions
	Luna Jacal	Rock structure Ocotillo / earth roofing Unmarked family graves Earthen berms and diversion structures	Structural integrity Wooden structural elements	Temperatures > 232 C	Avoid ground disturbance	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	La Coyota Community	Stone ruins Adobe ruins Wooden framing elements Trash Piles Irrigation structures Earthen berms and diversion structures Cemetery	Structural integrity Wooden structural elements Non-ferrous metal, glass, ceramic artifacts Wooden, glass, ceramic funerary objects	Temperatures > 232 C	Avoid ground disturbance Suppression Community map needed	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
	San Vicente Community	Stone ruins Adobe ruins Wooden framing elements Trash Piles Irrigation structures Earthen berms and diversion structures Cemetery	Structural integrity Wooden structural elements Non-ferrous metal, glass, ceramic artifacts Wooden, glass, ceramic funerary objects	Temperatures > 232 C	Avoid ground disturbance Community map needed	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
BUSINESS: The Candelilla Wax Industry	Wax camps and wax factories	Fireboxes Firebox pits Wax vats Wax strainers Sleeping shelters	Structural integrity Wooden structural elements Non-ferrous metal, glass, ceramic artifacts	Temperatures > 232 C	Avoid ground disturbance	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
COMMUNICATION	Telegraph and telephone lines	Wooden poles Glass insulators Wire	Wooden fixtures Patination surface on insulators	Temperatures > 232 C	Avoid ground disturbance	Manual fuel reduction around burnable structures and features
ARCHITECTURE: Vernacular Architecture:	Indigenous construction in remote frontier locations	Jacal structures, Dugouts, Adobe and rock masonry residential structures, Outbuildings, Masonry dams	Structural integrity Unique wooden structural elements Non-ferrous metal, glass, ceramic artifacts Wooden, glass, ceramic funerary objects	Temperatures > 232 C	Avoid ground disturbance Suppression on structures with combustible elements	Manual fuel reduction around burnable structures and features Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
ARCHITECTURE: Rustic Architecture:	Civilian Conservation Corps	Stone cottages Rock masonry headwalls, retaining walls, and buttress walls on roads and trails	Commercial value (lodging) Interpretive value Wooden structural elements	Heat spalling of plasters Blistering of painted surfaces Electrical utility lines Temperatures > 135 C	Avoid ground disturbance Suppression on structures with combustible elements	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
TECHNOLOGY:	Mining and mineral	Shafts and adits	Interpretive value	Temperatures > 135 C	Avoid ground	Manual fuel reduction around

Big Bend National Park Cultural Resources at Risk from Fire

Historic Context	Resource Type	Elements	Elements or Values at Risk	Risk Conditions	Management Objectives	Treatment or Prescriptions
Extraction of Raw Materials	extraction and processing	Rail transfer system Equipment mounting platforms Loading chutes Retorts Condensers Management infrastructure buildings Community structures Cemetery Trash piles	Structural integrity Wooden structural elements Non-ferrous metal, glass, ceramic artifacts Wooden, glass, ceramic funerary objects		disturbance Suppression on structures with combustible elements Prevent fire from falling into mine shafts	burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
TRANSPORTATION: American Indian travel routes	Comanche Trail, river crossings, routes through major terrain features	Entrenched trail at stream crossings Vegetation pattern defines trail	Loss of defining vegetation pattern	Moderate intensity fire	Avoid ground disturbance	Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
TRANSPORTATION: Mining	Puerto Rico Ore Tramway, Ore Road, Mariscal Mine haul road	Tramway towers Terminal ruin Cable Ore buckets	Interpretive value Wooden structural elements	Temperatures > 50 C	Avoid ground disturbance Suppression on structures with combustible elements	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
TRANSPORTATION: 19th and 20th Century Travel Routes	Pre-Park road system, NPS open roads	Roadbed Roadside debris Bridge ruins Highway camps	Non-ferrous metal, glass, ceramic artifacts	Temperatures > 135 C	Avoid ground disturbance	Avoid highway camps and trash piles; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
TRANSPORTATION: C.C.C. Road Construction	Road alignment Bridges & culverts	Original vertical and horizontal alignment Stone masonry	Scenic entry into park Interpretive value Structural integrity	Heat spalling of mortar joints on road culverts/trail structures	Avoid ground disturbance	Manual fuel reduction around masonry structures; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
RELIGION: American Indian Ceremonial Practices	Vision Quest Sites, Calendric Sites, Medicine Wheels	Stone enclosures Stone alignments Commemorative cairns Burial cairns	Integrity of stone alignments, cairns, and enclosure walls		Avoid ground disturbance	Manual fuel reduction Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation
RELIGION: Euro-American Religious Practices	Churches, Private Chapels, Matachine Sites, Cemeteries	Foundations and walls Wooden framing elements Wooden crosses Glass and ceramic offering objects	Interpretive value Non-ferrous metal, glass, ceramic artifacts	Temperatures > 135 C	Avoid ground disturbance Suppression on structures with combustible elements	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation

Big Bend National Park Cultural Resources at Risk from Fire

Historic Context	Resource Type	Elements	Elements or Values at Risk	Risk Conditions	Management Objectives	Treatment or Prescriptions
EDUCATION: Special Populations: Frontier Schools	School buildings and sites	Foundations Walls Trash piles	Interpretive value Non-ferrous metal, glass, ceramic artifacts	Temperatures > 232 C	Avoid ground disturbance	Manual fuel reduction around burnable structures and features; Pretreatment: hand lines/ring firing; use water where possible to suppress; photo documentation

Appendix D. Plant and Animal Species referred to in this EA

Acorn woodpecker (*Melanerpes formicivorus*)
Alkali sacaton (*Sporobolus airoides*)
Alligator juniper *(Juniperus deppeana)*
Arizona cypress (*Cupressus arizonica)*
Beaver (*Castor canadensis*)
Bear grass or Sacahuista (*Nolina microcarpa*)
Beebrush (*Aloysia gratissima*)
Bermuda grass (*Cynodon dactylon)*
Big Bend gambusia (*Gambusia gaigei*)
Bighorn desert sheep (*Ovis canadensis* spp.)
Bigpod bonamia (*Bonamia ovalifolia*)
Bigtooth maple *(Acer grandidentatum)*
Black bear (*Ursus americanus mexicanus*)
Black-capped vireo (*Vireo atricapilla)*
Black grama *(Bouteloua eriopoda)*
Black phoebe (*Sayornis nigricans*)
Black-tailed jackrabbit (*Lepus californicus*)
Black-tailed rattlesnake (*Crotalus molossus)*
Blue grama *(Bouteloua gracilis)*
Bobcat (*Lynx rufus*)
Broadtail hummingbirds (*Selasphorus platycercus*)
Buffelgrass (*Pennisetum cilare)*
Bull muhly (*Muhlenbergia emersleyi*)
Bunched cory cactus (*Coryphantha ramillosa)*
Bushtits (*Psaltriparus minimus*)
Cactus wren (*Campylorhynchus brunneicapillus*)
California cottontop (*Digitaria californica*)
Candelilla (*Euphorbia antisyphilitica)*
Catclaw Acacia *(Acacia constricta)*
Catclaw Mimosa (*Mimosa aculeaticarpa var. biuncifera*)
Ceniza (*Leucophyllum minus*)
Chino grama *(Bouteloua breviseta*)
Chisos agave (*Agave glomeruliflora*)
Chisos coral root (*Hexalectris revolute*)
Chisos hophornbeam (*Ostrya chisosensis*)
Chisos metalmark (*Apodemia chisosensis*)
Chisos Mountain or Lateleaf oak (*Quercus tardifolia)*
Chisos Mountain hedgehog cactus (*Echinocereus chisoensis* var. *chisoensis*)
Chisos pinweed (*Lechea mensalis)*
Chaffey's cory cactus (*Escobaria* var. *chaffeyi)*
Coachwhip snake (*Masticophis flagellum***)**
Coahuila oak (*Quercus polymorpha*)
Colima warbler (*Streptanthus cutleri)*
Common black hawk (*Buteogallus anthracinus**)***
Common reed (*Phragmites australis**)***
Cottonwood (*Populus deltoides* var. *fremontii)*
Coyote (*Canis latrans*)
Creosote (*Larrya tridentata)*
Curve-billed thrasher (*Toxostoma curvirostre*)
Cutler's Twistflower (*Streptanthus cutleri)*

Dalea spp. (approximately 12 species)
Deer muhly (*Muhlenbergia rigens)*
Dense cory cactus (*Escobaria dasyacantha* var. *dasyacantha)*
Desert willow (*Chiloensis linearis*)
Dog cholla (*Opuntia schottii*)
Douglas fir *(Pseudotsuga menziesii)*
Duncan's cory cactus (*Coryphantha duncanii)*
Elf owls (*Micrathene whitneyi*)
Emory oak (*Quercus emoryi)*
Evergreen sumac ((*Rhus virens* var. *choriophylla*)
Fragrant ash (*Fraxinus cuspidata*)
Giantreed (*Arundo donax)*
Glass Mountain coral root (*Hexalectrus nitida)*
Gnatcatchers (*Polioptila caerulea*)
Golden eagle (*Aquila chrysaetos)*
Golden-spined prickly pear (*Opuntia aureispina)*
Graves oak (*Quercus gravesii)*
Gray breasted jay (*Aphelocoma ultramarina*)
Gray fox (*Urocyon cinereoargenteus*)
Gray hawk (*Asturina plagiata*)
Gray oak (*Quercus grisea)*
Greater western mastiff bat (*Eumops perotis californicus)*
Green sprangletop (*Lepochloa dubia*)
Guayacan *(Guaiacum angustifolium)*
Guadalupe fescue (*Festuca ligulata*)
Hairy grama *(Bouteloua hirsuta)*
Harvard agave (*Agave harvardiana*)
Harvard's stonecrop (*Sedum harvardii)*
Harvard plum (*Prunus harvardii*)
Hetchia or falseagave (*Hechtia texensis)*
Hinckley's oak (*Quercus hinckleyi*)
Javalina (*Pecari tajacu)*
Johnson grass (*Sorghum halepense)*
Leatherstem (*Jatropha dioica*)
Lechuguilla (*Agave lechuguilla)*
Lehmanns lovegrass (*Eragrostis lehmanniana)*
Little-leaf brogniartia (*Brogniartia minutifolia)*
Lloyd's Mariposa cactus (*Sclerocactus mariposensis*)
Loggerhead shrike (*Lanius ludovicianus*)
Long-spur colombine (*Aquilegia longissima)*
Lovegrass (*Eragrostis* spp.)
Mariola *(Parthenium incanum)*
Mesquite *(Prosopis glandulosa)*
Mexican buckeye (*Ungnadia speciosa*)
Mexican gray wolf (*Canis lupus baileyi)*
Mexican long-nosed bat (*Leptonycteris nivalis*)
Mexican pinyon (*Pinus cembroides*)
Mexican spadefoot toad (*Spea multiplicata*)
Mockingbird (*Mimus polyglottos)*
Mountain lion (*Puma concolor)*
Mountain mahogany (*Cercocarpus montanus*)
Mule deer (*Odocoileus hemionus*)

Netleaf oak (*Quercus rugosa*)
Northern Aplomado falcon (*Falco femoralis septentrionalis)*
Northern flicker (*Colaptes auratus*)
Ocotillo *(Fouqueria splendens)*
Peregrine falcon (*Falco peregrinus)*
Pinyon ricegrass (*Pipochaetum fimbriatum*)
Ponderosa pine *(Pinus ponderosa)*
Prickly pear (*Opuntia* spp.)
Puckering nightshade (*Nectouxia formosa)*
Purple gay mallow (*Batesimalva violacea)*
Redberry juniper (*Juniperus pinchottii)*
Red oak (*Quercus rubra)*
Resurrection fern (*Selaginella lepidophylla*)
Rio Grande leopard frog (*Rana berlandieri*)
Roadrunner (*Geococcyx californianus*)
Robert's stonecrop (*Sedum robertsianum)*
Rock Squirrel (*Spermophilus variegates)*
Rufous towhe (*Pipilo erythrophthalmus)*
Russian thistle (*Salsola kali)*
Saltcedar (*Tamarix ramossissima)*
Scotts oriele (*Icterus parisorum*)
Screech owls (*Otus asio)*
Screwbean *(Prosopis pubescens)*
Scrub Oak (*Quercus turbinella*)
Sea urchin cactus (*Echinocactus asterias*)
Shorthorn jefea (*Jefea brevifolia)*
Shrubby groundsel (*Baccharis halimifolia)*
Sideoats grama *(Bouteloua curtipendula)*
Sierra del Carmen oak (*Quercus carmenensis)*
Sierra del Carmen whitetail deer (*Odocoileus virginianus)*
Silver-spined cholla (*Opuntia imbricata* var. *argentea)*
Skeletonleaf goldeneye (*Viguiera stenoloba*)
Slender Oak or Chisos oak (*Quercus graciliformis)*
Slimleaf vauquilinia (*Vauquelinia corymbosa* subsp. *angustifolia*)
Southwestern willow flycatcher (*Empidonax traillii extimus*)
Sotol *(Dasylirion wheeleri)*
Swallow spurge (*Chamaesyce golondrina)*
Tall-stemmed paintbrush or Squawflower (*Castilleja elongata* or *C. integra* var. *integra,* taxonomy questionable*)*
Tarbush *(Flourensia cernua)*
Texas antelope (*Antilocapra americana* and *A. mexicana)*
Texas hornshell (*Popenaias popei*)
Texas horned lizard (*Phrynosoma cornutum)*
Texas largeseed bittercress (*Cardamine macrocarpa* var. *texana)*
Texas madrone *(Arbutus xalapensis [texana])*
Texas persimmon (*Diospyros texana*)
Texas purple spike (*Hexalectris warnockii)*
Three-awns (*Aristida* spp.)
Three-tongued spurge (*Chamaesyce chaetocalyx* var. *triligulata)*
Tobosagrass *(Hilaria mutica)*
Trans-Pecos maidenbush (*Andrachne arida)*
Trans-Pecos rat snake (*Bogertophis subocularis*)

Striped Skunk (*Mephitis mephiis*)
Turkey vulture ***(****Cathartes aura)*
Two-Bristle rock daisy (*Perityle bisetosa* var. *bisetosa)*
Variable oakleaf caterpillar (*Lochmaeus manteo*)
Slimleaf rosewood (*Vauquelinia corymbosa* var. *heterodon)*
Weeping juniper (*Juniperus flaccidus)*
Western diamondback rattlesnake (*Crotalus atrox*)
Western pipistrelle (*Pipistrellus Hesperus*)
White column cactus (*Escobaria albicolumnaria*)
Willow, Goodding (*Salix gooddingii*), Black *(S. nigra),* Coyote *(S. exigua)*
Wright silktassel (*Garrya wrightii)*
Yellow bells (*Tacoma stans*)
Yellow-billed cuckoo (*Coccyzus americanus*)
Yellow-breasted chat (*Icteria virens auricollis*)
Yellow-nosed cotton rat (*Sigmodon ochrognathus*)
Yucca (6 *Yucca* spp.)

Appendix E: Watershed areas and potential impacts following high-severity fire

Soils Mapping Unit	Watersheds	Area (Approx)	Soil Characteristics	Slope % (mostly)	*Vegetation*	Susceptibility to erosion & debris flows following high-intensity, widespread fire
BRG Brewster Rock Outcrop Complex Very Steep	Around the west and north sides of the Basin.		Shallow to very shallow well-drained soils formed on rolling to very steep igneous mountains with rock outcrops. About 1/3 of the soil is clay, with cobbles and gravel making up 35-70% of the soil volume.	20-45 some vertical walls.	Vegetation in rock fissures and lower slopes. Includes Mexican pinyon pine, juniper, oaks, with shrubby Texas Madrone, mountain mahogany, evergreen sumac, littleleaf sumac, skeletonleaf goldeneye, and grasses sideoats grama, cane bluestem and threeawns.	Water erosion and debris flows are a hazard with steep slopes, shallow depth to bedrock (4-20 inches) and a clay layer slowing infiltration. Cobbles and gravel together with grass cover reduce surface erosion on some areas.
LMF –Liv Mainstay Rock Outcrop Complex Steep	South of trail to Laguna Meadows to ….. Chisos Basin		Liv soils are deep (60-80 inches), well drained, moderately slowly permeable soils formed in clayey cobbly and gravelly materials over igneous bedrock. Mainstay soils are shallow (10 20 inches), well-drained on uplands Gravelly or cobbly with 35-80% coarse fragments by volume.	2-45	On Liv soils vegetation is grass with some areas having an overstory of oaks, junipers and pinion pines. Grasses are mainly grama, bluestem, muhly, and threeawn. Mainstay soils support Pinyon pine, oaks, junipers, Texas Madrone, bigtooth maple, sumacs, semi-succulents and grasses.	About 40 inches to bedrock and 35-60% by volume of cobbles and gravel. Surface runoff is rapid and permeability moderately slow. With steep slopes water erosion is a severe hazard. Debris flows likely. Surface runoff is rapid and permeability moderately slow. Rooting depth is shallow to less than 20 inches to bedrock. Water erosion is a severe hazard because of steep slopes. Debris flows likely.
PRF Puerta Madrone Complex Steep			Shallow and moderately deep, steep, very gravelly soils over 6000 ft.	20-45	Pinyon pine, oaks, Arizona Cypress with Ponderosa pine and Douglas fir on north slopes and canyon bottoms.	Puerta soils are ~50% of the unit and have rapid runoff and gravelly, silty loam to bedrock at 20 inches. Madrone soils are ~35% more permeable in the upper layers with clayey soils at bedrock ~32 inches.
ERF Ector – Rock Complex Steep	SW of Laguna Meadow		Shallow or very shallow, well drained soils that are moderately permeable above a very slowly	Up to 60		Depth to underlying limestone bedrock is 6-20 inches. Very slowly permeable and well drained. Runoff

			permeable limestone bedrock. They formed in loamy residuum. Cobbles make up 0-20% of soil volume			very high on slopes over 5% Erosion Low Debris flows:Low
HRF- Hurds Very Cobbly Loam Steep	Green Gulch Pine Canyon ?		Deep, very gravelly and very cobbly well-drained soils on igneous hills and mountains at 5,000-6,000ft.	20-45	Mexican pinyon pine, redberry juniper, gambel oak, catclaw, catclaw and foothill basketgrass, Mexican sagewort, wolftail, deer muhly, bracken fern, little bluestem, hairy grama and cane bluestem.	Although these soils are deep ~60 inches and well drained, low water holding capacity and steep slopes make water erosion a severe hazard. Debris flowsLow
HRD - Hurds Very Gravelly Sandy Loam Rolling	Green Gulch Pine Canyon bottom of slopes		Deep, very gravelly soils in valleys and foot of slopes from 4,500-5,600 feet.	3-20	Mexican buckeye, foothills basetgrass, littleleaf leadtree, Apacheplume, juniper, sotol, catclaw, agave, hairy grama little bluestem and cane bluestem.	These soils are well drained deep and and moderately permeable. Water holding capacity is low and slopes are moderate making water erosion a moderate hazard. Debris flows: Low

Table compiled from Soil Survey of Big Bend National Park (1985), and USDA Official Soil Series Descriptions (on line, April 2004).

Soil Mapping Unit: An area of the landscape where soils have the same or similar characteristics (Buol et al, 1997).

Watersheds, Slopes and Acres: Supplied by Jeffrey Bennett park hydrologist, April, 2004

Watershed	Acres (approximate)	% slope-highest elevation in watershed	% slope-middle elevation in watershed	% slope-lowest elevation in watershed
Green Gulch	2367	100	68	6.7
Northwest Undifferentiated	424			
Oak Canyon	3804	223	51	6
Boot Canyon	845	100	35	20
Juniper Canyon	3136	100	50	5.7
Cattail Canyon	1487	42	51	80
Western Undifferentiated	866			
Pine Canyon	3189	165	51	7.5
Northeast Undifferentiated	2797			
Blue Creek Canyon	1143	200	40	20
South rim Undifferentiated	1202			

References

1. Soil Survey Staff, Natural Resources Conservation Service, United States Department of Official Soil Series Descriptions. Available online. Accessed 26 April 2004 http://soils.usda.gov/soils/technical/classification/os

2. *Soil Survey of Big Bend National Park.* 1985. U.S Department of Agriculture. NRCS.

3. Buol, S.W., F.D. Hole, R.J. McCracken and R.J. 1997. *Soil Genesis and Classification*. Fourth Editio Iowa State University Press.

4. Lynn Loomis: Soil Scientist, USDA- NRCS, Mar

5. Jeff Bennett: Hydrologist/ geologist, Big Bend N